RADIOLOGY

A MONTHLY JOURNAL DEVOTED TO CLINICAL RADIOLOGY AND ALLIED SCIENCES

EDITOR

Howard P. Doub, M.D.
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A Limited Survey of Radiation Exposure from Dental X-ray Units[1]

ROBERT O. GORSON, M.S.,[2] RONALD M. HALVORSEN, B.S., JESSE LIEBERMAN, M.S.,[3] and EDWARD V. AITKEN, M.S.

THE DEPARTMENT of Public Health of the City of Philadelphia, as a part of its expanding program in radiation hazard control, instituted in 1956 a study of radiation exposure from various medical x-ray units. Of the x-ray machines commonly used for medical diagnosis, dental units were chosen for initial investigation because of their number and wide use and because the training of personnel in the measurement of their radiation characteristics is relatively easy. The purpose of the limited survey described below was to estimate how much radiation dentists, their assistants, and their patients are receiving and to provide a basis for consideration of practical methods for reducing unnecessary radiation exposure.

METHODS

Measurements made on 56 dental x-ray units are included in the present study. Thirteen dental units were in city clinics and institutions, one was in a private hospital, and the remaining 42 were in the offices of dentists engaged in private practice. All calibrations and radiation surveys were performed under the operating conditions normally employed by the dentist in charge. In most instances, information concerning the tube potential and the total filtration was either lacking or was considered unreliable. The following measurements were made:

1. The exposure dose rate in roentgens per minute was measured in air with Victoreen 25-r ionization chambers placed at the tip of the cone normally used.

2. The "quality" of the radiation was determined by measuring the half-value layer (h.v.l.) in aluminum. Calibrated aluminum filters, 6 inches square, were used for transmission measurements. The distance between the filters and the ionization chamber was about 11 cm.

3. The size of the primary x-ray beam at the tip of the cone was determined by exposing x-ray film at that position.

4. The scattered and leakage radiation field in the vicinity of the x-ray tube head, with the primary beam directed toward the floor, was investigated with an ionization rate meter. For these measurements, a cube of maple wood, 13 cm. on each side, was positioned at the tip of the cone to serve as a "phantom" head. The approximate exposure dose rate at 1 meter from the cone tip and in a direction perpendicular to

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[2] Department of Radiology, Hospital of the University of Pennsylvania, and consultant in radiological physics to the Department of Public Health, Philadelphia.

[3] Chief, Industrial Sanitation Section, Department of Public Health, Philadelphia.

TABLE I: RADIATION CHARACTERISTICS OF SURVEYED DENTAL X-RAY UNITS

Unit No.	Tube Current (ma)	Beam Diameter at Cone Tip (cm.)	Exposure Rate at Cone Tip (r/min.)	h.v.l (mm. Al)	Scattered and Leakage Radiation 1 Meter from Phantom Head (mr/hr.)
1	5	6	160	0.9	100
2	10	9	209	0.6	900
3	5	5	128	0.8	<10
4	10	6	34	1.0	200
5	10	5	89	1.0	100
6	9	9	185	0.5	1,500
7	10	5	210	0.7	400
8	10	9	192	0.7	900
9	10	9	98	1.1	200
10	10	12	87	1.7	>1,500
11	5	5	119	0.8	< 10
12	10	5.7	32	1.2	< 10
13	5	7	149	0.8	100
14	5	3.5	96	0.7	< 10
15	5	3.5	115	0.8	< 10
16	10	9	115	1.0	700
17	10	7	147	0.8	600
18	11	9	125	0.8	700
19	10	10	59	1.1	600
20	12	9	53	0.7	300
21	9	9	137	0.7	1,300
22	11	9	166	1.0	800
23	9	9	129	0.9	1,300
24	10	5	128	1.1	100
25	10	7	115	1.1	600
26	9	9	102	0.9	800
27	5	6	38	1.1	200
28	10	12	199	1.1	>1,500
29	5	9	94	0.6	700
30	10	9	132	0.9	1,000
31	5	5	134	0.6	200
32	5	5	138	0.7	200
33	12	8	98	1.4	500
34	10	5.5	141	0.7	600
35	13	7.5	175	0.7	600
36	..	6.3	98	0.8	700
37	13	5.5	151	1.4	1,500
38	10	5.5	139	1.0	600
39	10	5.5	76	2.0	600
40	9	7.5	158	0.6	500
41	..	6.3	92	0.8	600
42	10	8.8	165	1.0	1,400
43	18	10	275	1.2	>1,500
44	11	8	116	0.9	1,400
45	10	8	94	0.9	700
46	10	8	193	0.9	>1,500
47	10	6	74	1.2	600
48	..	8	72	0.7	300
49	10	6	54	1.5	200
50	10	8	183	0.7	800
51	15	8	207	0.8	>1,500
52	10	11	125	1.0	1,500
53	8	9	103	0.8	>1,500
54	10	10	41	2.6	1,000
55	15	8	95	1.0	>1,500
56	10	8	175	0.5	900

the primary beam axis was interpolated from the plotted data.

5. In order to estimate the exposure received by the dentists and their assistants, each was supplied with radiation monitoring film badges obtained from a commercial film badge service. The badges were worn about the chest for either one or two weeks. Each person monitored was asked to keep a record of the total milliampere-seconds of x-ray exposure made while in the vicinity of the x-ray machine. In some cases, the study was repeated.

6. In order to obtain an index of the ra-

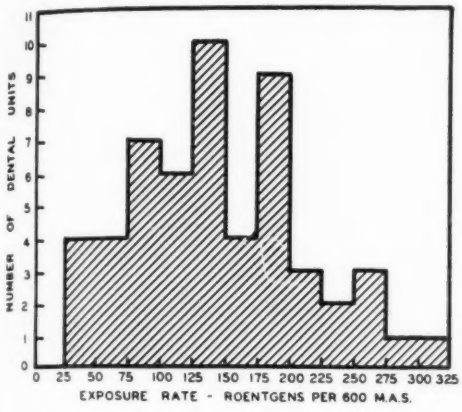

Fig. 1. Distribution of exposure rates measured in air at the tip of the cone. Values are in roentgens per minute normalized for a tube current of 10 ma.

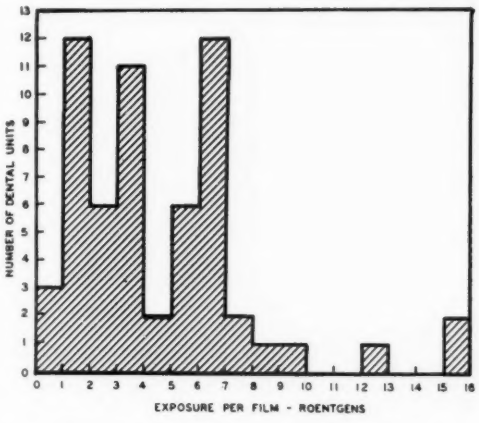

Fig. 2. Distribution of typical exposures in air at the tip of the cone for taking periapical molar roentgenograms on adults.

diation exposure to the patient, each dentist was asked for the exposure time he normally used for making periapical molar roentgenograms of adult patients. With this information and the measurements made of the exposure rate under the conditions of use, the exposure dose in roentgens at the tip of the cone, without back-scatter, was calculated for molar roentgenograms of adults.

The basic data are listed in Table I and the results are summarized in Table II. Graphs of the data distribution are presented in Figures 1 through 6. The results are discussed below.

RADIATION EXPOSURE TO THE PATIENT

1. *Radiation Exposure Rate:* The distribution of exposure rates measured in air at the tip of the cone is plotted in Figure 1. The values are in roentgens per minute, which in this case are normalized for a tube current of 10 ma. High exposure rates are not necessarily undesirable provided the exposure time is suitably controlled with an accurate short-range timer. Actually, high exposure rates can be helpful in reducing radiographic unsharpness due to motion. In this respect there are advantages in using high-kilovoltage x-ray apparatus, with their relatively high exposure rates. As far as the dose to the patient is concerned, the important consideration is the exposure per roentgenogram rather than the exposure rate.

2. *Exposure per Molar Roentgenogram:* In Figure 2 is shown the range in exposures given for periapical roentgenograms of mo-

TABLE II: SUMMARY OF RESULTS

Observation or Calculation	Number of Measurements	Range in Readings Maximum	Minimum	Mean Value	Median Value
Radiation exposure rate in air at cone tip: r per minute	56	275	32	125	125
Same, normalized for 10 ma: r per 100 mas	53	320	32	142	138
h.v.l. in millimeters of aluminum	56	2.6	0.5	1.0	0.9
Beam diameter at cone tip in centimeters	56	12	3.5	7.5	8.0
Exposure for periapical adult molar roentgenogram: r in air at cone tip	56	15.8	0.4	4.6	3.4
Scattered and leakage radiation at 1 meter from phantom head: milliroentgens per hour	56	>1,500	<10	...	600
Dosimeter film badge readings in milliroentgens, normalized for one week	140	1,400	0	45	20
Film badge exposure time in milliampere-seconds, normalized for one week	140	5,210	30	1,340	900

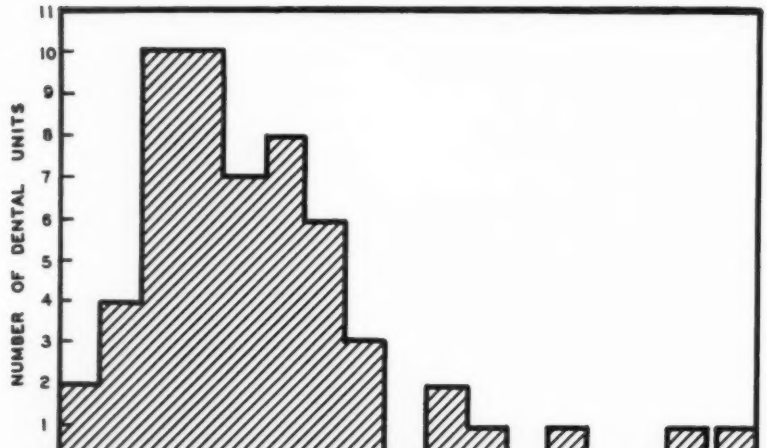

Fig. 3. Distribution of the radiation "quality" of the primary x-ray beam.

lars taken on adult patients with the dental x-ray machines included in this study. The exposure values are for readings taken in air and vary from 0.4 to 15.8 r. The corresponding skin dose to the patient would be 10 to 25 per cent greater, depending upon the field size and h.v.l. used in each case.

The exposure to the patient should be no greater than that required for adequate diagnosis. This will vary with the patient, the problem, and the technic chosen by the dentist. Exposures necessarily given for medical purposes are specifically excluded from the recommendations of the National Committee on Radiation Protection (1–3) and from the radiation safety codes of regulating agencies (4–6). Some writers still refer to the "threshold erythema dose" as a basis for establishing an acceptable dose level or "safe dose." Obviously, there is no "safe dose" as such. The acceptable exposure to the patient must be determined in the individual case on the basis of the relative diagnostic importance of the examination. In this respect, no safe exposure recommendations can replace sound judgment on the part of the dentist (7–14). The patient exposure is a function of the factors enumerated and discussed as follows.

FACTORS AFFECTING PATIENT EXPOSURE

1. *Half-Value Layer:* Some dentists insist upon high contrast roentgenograms that result from the use of radiation of low h.v.l., while others prefer the extended latitude in radiographic density obtainable with a greater h.v.l. For a constant film density, the skin dose, and to a lesser extent the integral dose, to the patient decreases with increasing h.v.l. (15–18). The h.v.l. may be increased by operating at higher x-ray tube potentials or by adding more filter to the x-ray unit or by both methods. Figure 3 indicates that the majority of the dental units surveyed during this study were producing radiation of lower h.v.l. than that recommended by the National Committee on Radiation Protection (a minimum of 1.5 mm. total aluminum equivalent filter, or approximately 1.2 mm. aluminum h.v.l. at 65 kvp) (1) or than that recommended recently by the American Academy of Oral Roentgenology (2 mm. aluminum equivalent total filtration) (19). It should be pointed out, however, that the total filtration cannot be determined with accuracy even if the tube potential is known. Information about the inherent filtration and its aluminum equivalent can

usually be obtained only from the manufacturer, if at all.

As far as the dose received by the patient is concerned, one need not care about either the actual tube potential or the total filter provided a measurement of the h.v.l. indicates that the combination is adequate. The h.v.l. *can* be measured for the operating conditions used. It would seem preferable and more logical, therefore, that all recommendations concerning total or added filter (and kilovoltage) be made in terms of minimum h.v.l.

2. *Radiographic Density:* Some dentists prefer roentgenograms with greater overall density than do other dentists. This is achieved by using greater radiation exposures, and to some extent by increasing the development time. In the interest of minimizing the exposure to the patient, the use of fast developers should be considered; it is better to overdevelop than to overexpose (7, 19).

3. *Film Speed:* Single-emulsion dental x-ray film with the resulting fine grain pattern and sharp definition is preferred by some dentists, while others feel that the ultra-fast films now available are quite suitable for accurate diagnosis. For the same radiographic density, the slow films require considerably more exposure than the ultra-fast films.

4. *Field Area:* Some dentists feel that it is practical to use a narrowly collimated x-ray beam for most of their dental radiography, while others require a larger field size. The choice, of course, depends upon the kind of examination and the size of the film. For periapical radiography, the maximum field sizes recommended by various authors range from 2.0 to 3.75 inches at the tip of the cone (7, 8, 19–24). As is indicated in Figure 4, many dental units included in this study used primary beams of greater diameter than recommended values. A minimal beam dimension is desirable because of (*a*) the slight reduction in the skin dose to the patient, (*b*) the considerable reduction in the integral dose to the patient, and (*c*) the reduction in the scattered radiation received by other

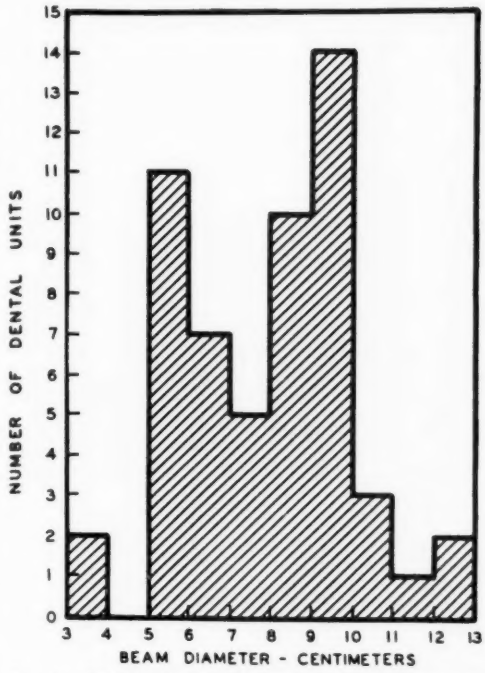

Fig. 4. Distribution of the diameter of the primary x-ray beam measured at the tip of the cone.

parts of the patient's body, by the dentist and by the film itself.

5. *Target-Skin Distance:* Most of the dentists whose x-ray units were included in this survey were using short cones with a target-skin distance of about 8 inches. Some authors have proposed that long cones be used in order to reduce the skin dose to the patient (9, 19–22, 25–28). The reduction in skin dose for dental radiography, however, is small because of the proximity of the film to the skin. Calculation shows that, for a fixed exposure to the film at 1 inch from the skin with a target-to-skin distance of 16 inches, the skin exposure is only about 10 per cent lower than for a target-to-skin distance of 8 inches, provided the beam diameter at the skin is the same. Reduction in integral dose is even less. Nevertheless, the "long-cone technic" is to be preferred if other factors, such as exposure time, do not contraindicate its use. If ultra-fast dental films can be used, their sensitivity will compensate for the reduction in exposure rate (29).

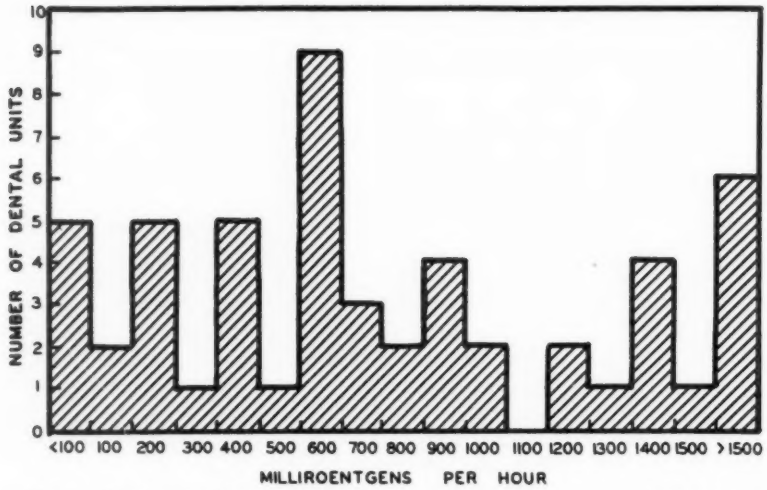

Fig. 5. Distribution of scattered and leakage radiation levels measured at a distance of 1 meter from the tip of the cone in a direction perpendicular to the beam axis. A 13-cm. cube of maple wood was used as a phantom head. Values are normalized for a tube current of 10 ma.

RADIATION EXPOSURE TO THE DENTIST

The distribution of scattered and leakage radiation measured at 1 meter from the tip of the cone and normalized for a tube current of 10 ma is plotted in Figure 5. The scattered radiation levels are dependent primarily upon the exposure rate and the useful beam size, and to a lesser extent upon the h.v.l. of the primary radiation. The leakage radiation through the tube housing was not measured separately in the present study (10, 23). The combined readings ranged from less than 20 mr per hour for five dental units to 1,500 mr per hour or greater for seven units. The median value was 600 mr per hour or 1/60 mr per mas.

The distribution of readings on film badges worn by the dentists and their assistants is plotted in Figure 6 against the exposure time in milliampere seconds. The median value was 20 mr per week. The corresponding median exposure time was 900 mas per week. The average of the film badge readings was 45 mr per week, or more than double the median value. Thus, as can be seen by inspection of Figure 6, a few dentists or their assistants were less careful in protecting themselves than were the majority. Of the 140 film badge readings, 11 were more than 100 mr per week, and 2 of these exceeded 300 mr per week. Personnel receiving the highest readings were not able to account for them.

In a similar study conducted by the Missouri Division of Health (30), the average of 94 film badge readings was 63 mr per week, with 15 readings exceeding 100 mr per week, including 6 which were greater than 300 mr per week. Forty-seven dentists and dental technicians were included in that study and all the badges were worn for two-week periods.

The present survey, of course, was subject to the usual uncertainties of film badge dosimetry. The reported readings are what the badges received. It is assumed that they were exposed only while they were being worn and that they were always worn when the persons concerned were exposed during the period of interest. There may be considerable error in the low readings. Nevertheless, it can be concluded with some confidence that, during the periods of study, the great majority of the personnel received considerably less than 100 mr per week, the maximum permissible *average* weekly dose to the total body for occupational exposure (2). However, the fact that some dentists can receive essen-

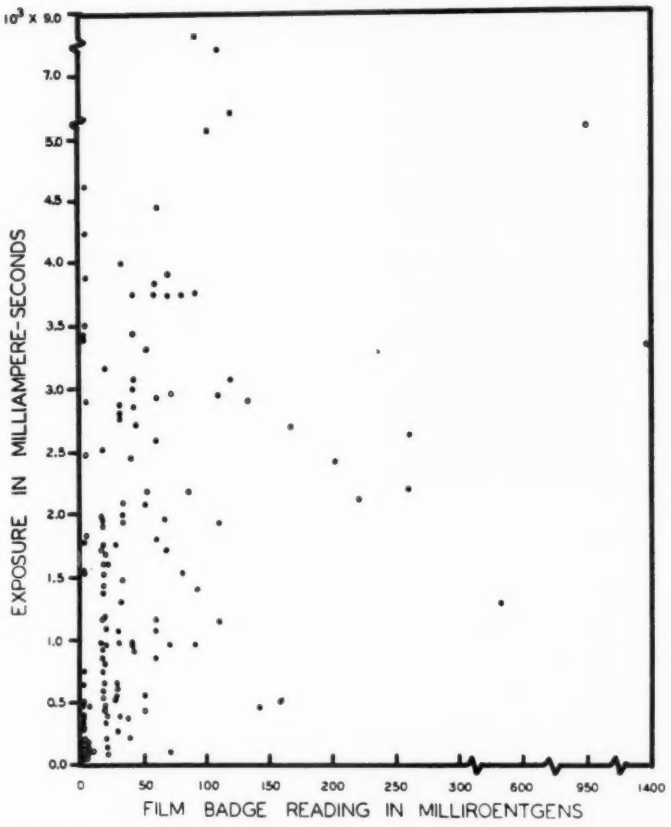

Fig. 6. Distribution of exposure dose readings for film badges worn by dentists and their assistants as a function of the exposure time. Open circles represent film badges worn for one week; solid circles film badges worn for two weeks.

tially no radiation exposure in the course of their work indicates that for others there is considerable room for improvement.

Various rules and technics for limiting exposure to dental personnel, such as rotating the position of the patient so that his back is toward the outside wall during radiography and standing as far from the patient and the x-ray unit as possible, have been adequately discussed in a number of other papers (1, 7–11, 19–30) and will not be repeated in detail here.

EFFECT OF HALF-VALUE LAYER ON DIAGNOSTIC QUALITY OF DENTAL ROENTGENOGRAMS

Performing a radiographic examination that is satisfactory for the diagnostic problem under consideration raises a question relevant to patient exposure: What are the criteria by which one can judge the diagnostic value of dental roentgenograms? There is no simple, unqualified answer. A poll among dentists might produce different answers, approaching in number the number of dentists included in such a survey. Two important factors affecting the exposure to the patient that may also affect the quality of the radiographic image are the h.v.l. of the radiation and the type of film used. As far as *documenting* the effect of these factors on *diagnostic quality* is concerned, the authors found the literature to be of little help Some investigators claim that the use of high-kilovoltage radiography, or the addition of heavy filtration, or

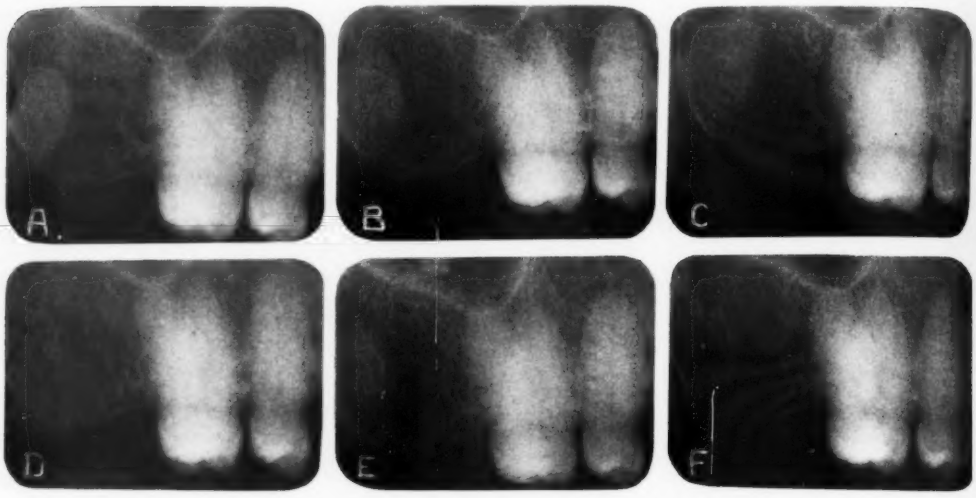

Fig. 7. The effect of increasing aluminum filtration on periapical roentgenograms made with a relatively slow, fine grain, single emulsion film (DuPont S-1). Exposure factors given in Table III. Added aluminum filters as follows: A. 0 mm. B. 1 mm. C. 2 mm. D. 3 mm. E. 4 mm. F. 5 mm.

the use of ultra-fast x-ray films, or combinations of these factors result in dental roentgenograms of greater diagnostic value than those made with more conventional technics (16, 20–22, 25, 31, 32). Others feel that such radiographs may actually be of inferior diagnostic value (7, 17, 24). There is little doubt that the radiographic contrast and roentgen image definition are affected (15–18), but, as Tuddenham has demonstrated in the case of chest radiography, there are other factors which, within certain limits, may be far more important than contrast and definition (33, 34).

The complex roentgen image cannot be analyzed in terms of oversimplified technics such as the measurement of the densities of films exposed with step wedges or the measurement of film resolution with wire-mesh screens. The psychologic factors must be considered. The perception of radiographic detail is a psychophysiologic process that cannot be quantitated in terms of the physical characteristics of the roentgenogram (35). It appears to the authors that investigations of radiographic technics for minimizing patient exposure must include careful objective evaluations of their diagnostic value. Such studies must be based on the detection of significant abnormalities (27) by a large group of dentists and dental radiologists, with careful attention to adequate control technics and unbiased scoring and analysis of the data.

Most of the dentists were advised to have additional aluminum filters installed in the dental units included in this survey. Recommendation of a specific amount presented a problem, for reasons discussed earlier. One of the authors, therefore, attempted a limited study to determine whether or not the addition of several millimeters of aluminum is likely to have an appreciable effect on the relative diagnostic quality of the dental roentgenograms. After a preliminary trial with a dental phantom consisting of Plexiglas and extracted molars, a series of dental roentgenograms were made for several patients with the exposure times adjusted to give nearly comparable densities over a range of added filter from 0 to 5 mm. of aluminum. An XRM model 2A self-rectified dental x-ray unit was used and operated at a rated potential of 65 kvp and with a tube current of 10 ma. The primary beam diameter was 2.5 inches at a target-to-cone-tip distance of 8 inches. According to the manufacturer, the total initial filtration was equivalent to 0.75 mm. of aluminum. The

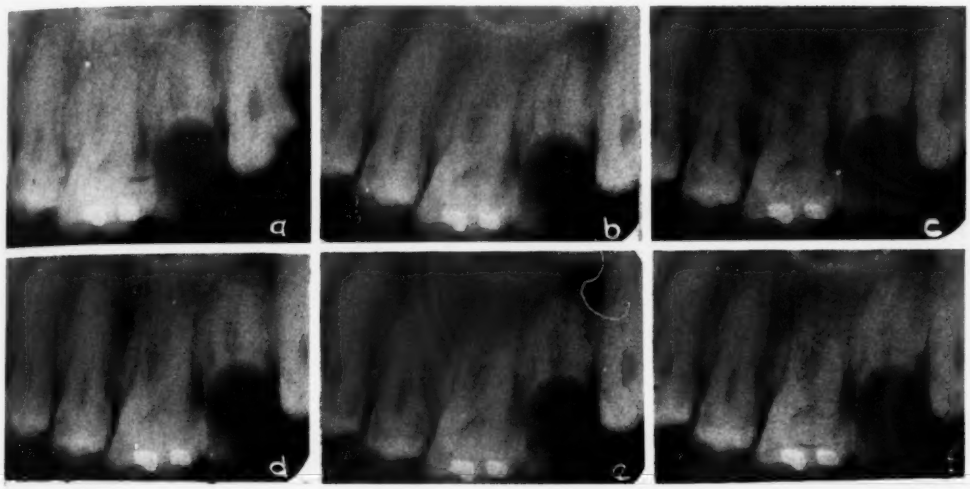

Fig. 8. Effect of increasing aluminum filtration on periapical roentgenograms made with a fast double emulsion film (Kodak Ultra Speed). Exposure factors given in Table III. Added aluminum filters as follows: *a*. 0 mm. *b*. 1 mm. *c*. 2 mm. *d*. 3 mm. *e*. 4 mm. *f*. 5 mm.

TABLE III: EXPOSURE FACTORS USED FOR ROENTGENOGRAMS IN FIGURES 7 AND 8

65 kvp; 10 ma; 0.75 mm. Al initial filtration; 6 cm. beam diameter at 8 inch TSD							
Added filter: mm. aluminum		0	1	2	3	4	5
Total filtration: mm. aluminum		0.75	1.75	2.75	3.75	4.75	5.75
Half-value layer: mm. aluminum		1.2	1.7	2.1	2.4	2.6	2.7
Du Pont Film Type S-1	Exp. time in seconds:	0.8	1.25	1.5	2.0	2.5	3.25
	Approx. skin dose	3.2 r	2.8 r	2.3 r	2.1 r	1.9 r	1.9 r
Kodak Ultra Speed Film	Exp. time in seconds:	0.2	0.3	0.4	0.5	0.6	0.8
	Approx. skin dose:	0.80 r	0.68 r	0.60 r	0.52 r	0.47 r	0.46 r

total filtration used for the roentgenograms therefore ranged from approximately 0.75 to 5.75 mm. of aluminum. The corresponding measured h.v.l. in aluminum varied from 1.2 to 2.7 mm.[4] The roentgenograms obtained with a fine-grain single-emulsion film (DuPont S-1) are shown in Figure 7. Another set of radiographs made on another patient with Kodak Ultra-speed film is presented in Figure 8. The exposure factors and patient skin dose are listed in Table III. The films were processed in Kodak Rapid Developer for five minutes at a temperature of 68° F.

[4] The h.v.l. determinations were higher than expected (15, 36) and indicate that the tube potential and the initial filtration may have been greater than the manufacturer's ratings. All measurements were made with a Victoreen 25-r condenser ionization chamber that has been intercompared over the h.v.l. range with a secondary standard calibrated by the National Bureau of Standards.

Eight radiologists and 10 dentists on the staff of the Evans Dental Institute of the University of Pennsylvania and the University of Pennsylvania Hospital were asked to review the second series of roentgenograms made with the ultra-fast film and to arrange them in order of preference for diagnostic readability, using any criteria that each felt was of importance. Each reviewer was also requested to repeat the procedure with a second set of identical roentgenograms arranged in a different order. The *consistency* with which each individual repeated the selection of films in order of preference was considered to be a measure of the relative importance of the amount of filtration in affecting their "diagnostic quality." The results are illustrated in Figure 9. The number of reviewers is plotted against the order of preference for each film, identified by the amount of

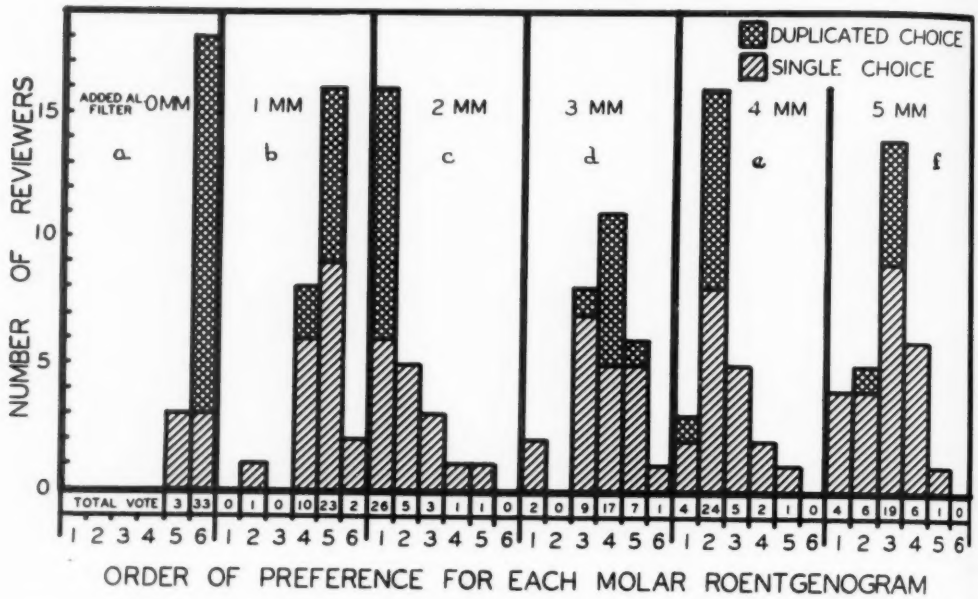

Fig. 9. Review of the roentgenograms shown in Figure 8 by 8 radiologists and 10 dentists. Each reviewer had two opportunities for selecting the films in order of preference; the maximum total vote for any preference position, therefore, is 36. The degree of *consistency* in selecting a film in the same order twice is indicated by the number of *duplicated* votes the roentgenogram received for the order specified.

added filter. The total vote at the bottom of each column indicates the final order of preference by the reviewing group as a whole. Since there were 18 reviewers, each of whom voted twice, the maximum possible vote for any given choice is 36. The degree of *consistency* in selecting a film in the same order twice is indicated by the number of *duplicated* votes the roentgenogram received for the order specified. Consider, for example, roentgenogram "*c*" taken with 2 mm. of added aluminum filter. Figure 9 shows that, although 16 reviewers selected it for first preference, only 10 were consistent in making the same selection twice. Hence the total vote for first preference is 26 (6 single and 10 double votes). Only one dentist and one radiologist was completely consistent with himself in choosing all of the films in the same order for the two successive readings. Most reviewers had difficulty in selecting all but the "poorest" film, the one taken with no added filter. In addition, most of the readers felt that all but the poorest roentgenogram were satisfactory for diagnosis.

The tentative conclusion to be drawn from this limited study is that the h.v.l. within a range of at least 1 to 3 mm. of aluminum is not an important factor in determining the diagnostic quality of periapical roentgenograms. Other factors of perhaps greater importance, such as the motion of the patient and adjusting of exposure time to obtain films of exactly comparable radiographic density, were difficult to control. It is quite probable that these factors were largely responsible for the radiograph taken with 2 mm. added aluminum filter receiving the highest rating for first preference and for the one made with no added filter having the highest rating for last preference. Different results might be obtained with a more exhaustive investigation.

On the basis of the above study, the experience obtained during the survey of the dental units, and the opinions and recommendations of other writers and groups, the authors feel that, whenever it is practical, all dental x-ray units should have enough added filter so that, with the tube

potentials used, the h.v.l. in aluminum of the primary beam is at least 1.8 mm. and preferably above 2.0 mm. When it is not practical to measure the h.v.l. or when the maximum tube potential available is less than 60 kvp, so that it is impractical to obtain the minimum h.v.l., then the total amount of *added* filter (exclusive of the inherent filtration of the x-ray tube and oil) should be at least 2.0 mm. of aluminum.

SUMMARY AND CONCLUSIONS

1. The radiation exposure to the dentists and their assistants included in this study appears to be on the average considerably less than 100 mr per week, the maximum permissible *average* weekly dose to the total body for occupational exposure as recommended by the National Committee on Radiation Protection. However, the fact that many dentists can receive very low radiation exposure in the course of their work indicates that for others there is considerable room for improvement.

2. The majority of the 56 dental x-ray units included in this study were producing excessively "soft" radiation, indicating that most of them had insufficient added aluminum filtration. It is recommended that dentists use operating tube potentials and added filter combinations so that the aluminum h.v.l. of the primary beam is not less than 1.8 mm. and preferably greater than 2.0 mm.

3. About 50 per cent of the dental units had primary beam diameters at the tip of the cone which were larger than necessary for routine dental radiography. It is recommended that the beam diameter be limited to not more than 3.0 inches, and preferably to less than 2.5 inches.

4. The variation in the radiation characteristics of the dental units, and differences in radiographic technic and film types used by the dentists, resulted in radiation exposure to the patient ranging from 0.4 to 15.8 r (in air at the skin) for periapical molar roentgenograms.

5. A limited study was done on the effect of added aluminum filtration on the diagnostic quality of molar roentgenograms. The results indicate that the diagnostic quality of dental radiographs is not a sensitive function of total filtration ranging from about 1 to 6 mm. of aluminum for an operating potential of 65 kvp (or within a h.v.l. range of 1 to 3 mm. of aluminum). The results indicate further that normally it should not be necessary to exceed an air exposure dose to the patient of 3.0 r for a periapical molar roentgenogram, and it is feasible to reduce such exposures to less than 1 r with currently available technics.

6. A review of the radiographic technics for minimizing patient exposure indicates the necessity for a comprehensive and objective study of all the factors (physical, psychological, and physiological) that determine the diagnostic adequacy of dental roentgenographic examinations.

ACKNOWLEDGMENTS: We are pleased to acknowledge the excellent co-operation of the dentists whose x-ray units were surveyed in this study. We wish, also, to express our sincere appreciation to the dentists and radiologists who assisted in the comparison of the dental roentgenograms, to Dr. William Tuddenham for his advice and encouragement, and to Mr. Robert Handler, Mr. Walter Sobelesky, and Mrs. Trudy Fielding for technical assistance.

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SUMMARIO IN INTERLINGUA

Un Limitate Enquete In Re Le Exposition Raditional Ab Roentgeno-Machinas Dental

In un studio de 56 roentgeno-machinas dental, initiate per le Departimento de Hygiene Public del Citate de Philadelphia, le sequente observationes e recommendationes esseva facite:

1. Le exposition radiational del dentistas e lor assistentes pareva attinger un nivello medie considerabilemente infra le 100 mr per septimana que es le maximo permissibile del dose septimanal *medie* al corpore total in expositiones occupational secundo le recommendationes del Committee National de Protection Radiational. Tamen, le facto que il es possibile pro multe dentistas laborar con bassissime nivellos de exposition radiational in le curso de lor practica indica que pro alteres il existe grande possibilitates de melioration.

2. Le majoritate del 56 roentgeno-machinas includite in iste studio produceva un excessivemente "molle" radiation. Isto indica que le majoritate habeva insufficiente additiones de filtration de aluminium. Es recommendate que le dentista usa potentiales de tubo e combinationes de filtros additional de maniera que le spissitate aluminial del medie valor pro le fasce primari es non minus que 1,8 mm e preferibilemente plus que 2,0 mm.

3. Circa 50 pro cento del machinas dental habeva, al puncta del cono, diametros del fasce primari in excesso de lo que

es necessari in le routine del radiographia dental. Es recommendate limitar le diametro del fasce a non plus que 3,0 pollices, e preferibilemente a infra 2,5 pollices.

4. Variationes in le characteristicas radiational del machinas dental, insimul con differentias del technica radiographic e del typo de pellicula usate per le dentistas, resultava in expositiones radiational del patientes amontante a inter 0,4 e 15,8 r (in aere al pelle) pro roentgenogrammas molar periapical.

5. Esseva executate un studio relative al effecto de filtration additional per aluminium super le qualitate diagnostic de roentgenogrammas molar. Le resultatos indica que le qualitate diagnostic de radiogrammas dental non es sensibilemente un function del filtration total inter le limites de 1 mm e 6 mm de aluminium pro un potential operatori de 65 kvp (o, in altere terminos, a spissitates de medie valor inter le limites de 1 mm e 3 mm de aluminium). Le resultatos indica in plus que normalmente il non deberea esser necessari exceder un dosage de exposition in aere al patiente de 3,0 r pro un roentgenogramma molar periapical e que il es possibile reducer ille dosage a minus que 1 r con le application del currentemente disponsibile technicas.

6. Un revista del technica radiographic pro reducer al minimo le exposition del patiente indica le necessitate de un studio comprehensive e objective de omne le factores (physic, psychologic, e physiologic) que determina le adequatia diagnostic de roentgeno-examines dental.

Radiologic Aspects of Craniopharyngiomas[1]

DONALD J. BARNETT, M.D.[2]

CRANIOPHARYNGIOMAS, while not rare, are not among the more frequently occurring intracranial tumors. That these neoplasms do not develop more often is surprising, for Shanks and Kerley, who carefully sectioned the contents of the sella turcica in a number of patients, found it to contain remnants of Rathke's pouch in 20 per cent. From this it might be concluded that only an occasional cell rest exhibits uncontrolled growth with production of the type of neoplasm known as craniopharyngioma.

Between the years 1932 and 1952, brain tumors were diagnosed at the Neurological Institute of New York City in 822 patients; of these 59 were craniopharyngiomas. From 1952 through 1956, 831 patients were signed out of the Neurological Institute as having brain tumors, of which 25 were craniopharyngiomas. In only 62 of the total of 84 cases were both adequate charts and roentgenographic data available. For the purposes of this study, the remaining 22 were discarded. There were 32 males and 30 females in the series. A tissue diagnosis was made in 48 patients, and the other 16 cases were diagnosed clinically and roentgenologically.

TABLE I: AGE DISTRIBUTION OF 62 PATIENTS

Ages (yr.)	No.
0–10	10
11–20	18
21–30	9
31–40	7
41–50	8
51–60	4
61–70	4
No age given	2
Youngest	2 yr.
Oldest	67 yr.

TABLE II: SIZE OF SELLA TURCICA

Anteroposterior diameter	
<17 mm.	46 cases
>17 mm.	16 cases
Vertical measurement	
<14 mm.	46 cases
>14 mm.	15 cases (1 could not be determined)

SYMPTOMS

The area in which these tumors develop is crowded with sensitive structures: *i.e.*, the optic chiasm, the third ventricle, and the hypothalamus. As might be expected, loss of vision of various degrees was generally the first and most common symptom. Endocrine disturbances appeared as the tumors encroached on the pituitary gland. The third ventricle was compressed by the sheer volume of the tumor, with ultimate lateral ventricular dilatation. This in turn was followed by headache, nausea, and vomiting. The youngest patient was two years old, and 4 were over sixty. All of the intervening decades were represented (Table I).

PATHOLOGY

Craniopharyngiomas are of squamous origin. A pouch (Rathke's) develops from the dorsal aspect of the oral cavity of the fetus about the third month of gestation. At the same time there develops a protrusion downward from the floor of the third ventricle, coming to rest behind and adjacent to the oral pouch. As development proceeds the oral pouch contracts and elongates, forming the craniopharyngeal duct. Ultimately, this will disappear. The remainder of the pouch develops into the pars anterior and the pars intermedia. The cranial protrusion from the third ventrical produces the pars nervosa.

At the junction of the craniopharyngeal duct with the dilated superior portion of the oral pouch there are two lateral processes called tuberal processes. These give

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Fig. 1. Example of pointing of the anterior clinoid processes in a proved case of craniopharyngioma.
Fig. 2. Increase in density of the sella turcica associated with calcific deposits in a craniopharyngioma.

rise to the pars tuberalis, and fuse to the anterior aspect of the infundibulum. It is from these remnants of the duct that craniopharyngiomas arise. They may be solid or cystic masses and may contain rudimentary enamel organs. Calcium is a common constituent.

ROENTGEN SIGNS

The sella turcica usually was not enlarged when a craniopharyngioma was present (Table II). In a few patients, however, it was very large, and in one instance the vertical diameter could not be determined because the floor of the sella turcica had disappeared. At the Neurological Institute the upper limit of normal for the anteroposterior diameter of the sella turcica is 17 mm. and for the depth 14 mm. In about half the patients the anterior clinoids escaped erosion (Table III). When the anterior clinoid processes were involved, the inferior surfaces were eroded, causing these bony processes to be pointed. The dorsal surfaces rarely showed any change from normal (Fig. 1).

The dorsum sellae and the posterior clinoid processes suffered the most from erosion. In only 12 patients was the dorsum sellae normal; in three times that number there was moderate to severe loss of bony substance. Almost half of the patients showed no change in the floor of the sella turcica, with the remainder showing slight to severe loss.

TABLE III: EROSIONS OF THE SELLA TURCICA

	None	Slight	Moderate	Severe
Anterior clinoids	31	16	11	1
Posterior clinoids and dorsum sellae	12	9	18	20
Floor	26	7	15	8

An unexpected finding was an *increase* in density of various portions of the sella turcica. Two patients exhibited an increased opacity of all the clinoid processes as well as of the floor (Figs. 1 and 2). Another patient showed an increase in calcium in the anterior clinoid processes and floor only. In 4 the floors appeared dense, with varying degrees of erosion of the clinoid processes. In only 1 patient was there evidence of increased opacity of the sella turcica without any other abnormality; in the remainder, erosion or enlargement of the sella or calcific deposits were present. Pancoast, Pendergrass, Schaeffer and Hodes in their excellent reference

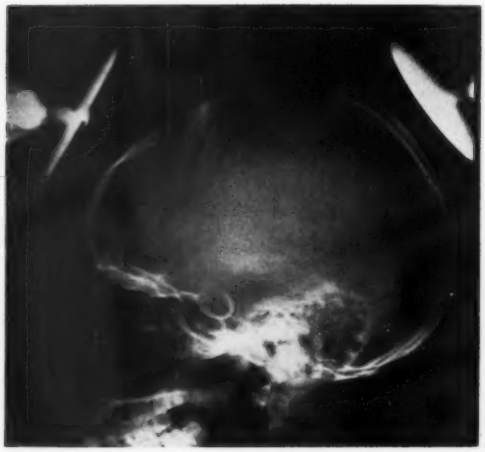

Fig. 3. Increase in density of the sella turcica in the presence of a craniopharyngioma without other abnormalities.

work state that a dense sella turcica can occur as a congenital variant. In our experience it is unusual to find increased opacity of that structure, and this has been associated in most instances with a suprasellar or a parasellar mass. Occasionally the observation has been made in patients with pituitary adenomas following external roentgen therapy and with parasellar meningiomas. These latter have an altered trabecular pattern that differs from that following irradiation or in the presence of a craniopharyngioma. In meningiomas the trabeculae are enlarged as well as dense. Shanks and Kerley mention thickening of the sella turcica in a patient who had a meningioma of the right side of the middle fossa. The cause of the increase in density in 8 patients is unknown.

TABLE IV: CALCIFICATION

Types*	
Linear	10
Flocculent	34
Location in relation to sella turcica	
Intrasellar	16
Suprasellar	30
Posterior	7
Anterior	1
Lateral	2
No calcification in 19 patients	

* Both types in some patients.

The presence of abnormal calcific deposits in and about the sella turcica was an important finding (Table IV). Frequently this was sufficient to permit diagnosis without additional roentgen examination. A few of the craniopharyngiomas calcified at the periphery only, showing a thin, curved calcific outline (Fig. 4). In about three-fourths of the cases with calcification this took the form of soft, flocculent, irregular densities that did not necessarily reflect the size of the tumor (Fig. 2). Calcium occurred in the suprasellar area, anterior or posterior to the sella turcica, or within it. Frequently the deposits were in more than one area. In 19 of the 62 cases (27 per cent) not sufficient calcium was present to be recognizable by the usual roentgen examination. In other words, calcification occurred in 73 per cent. In Cushing's series of craniopharyngiomas calcification could be recognized on routine skull films in 80 per cent. Lindgren and Di Chiro (2), however, found recognizable calcium in only 55 per cent of their patients. McKenzie (4) observed it in 71 per cent of his cases.

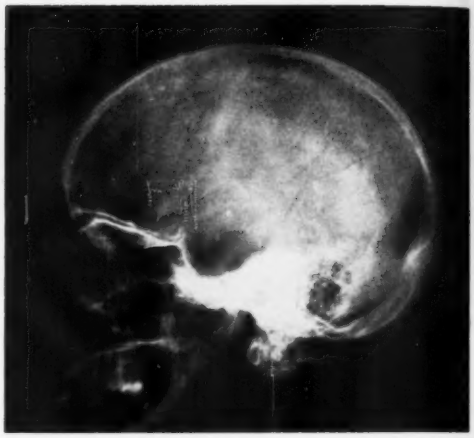

Fig. 4. Thin, curved calcific deposit at the periphery of a craniopharyngioma.

Forty patients were examined by pneumoencephalography or ventriculography. Only 2 failed to show compression of the third ventricle; in other words, 95 per cent of those examined had distortion of the third ventricle (Fig. 5). Compression was exerted from below, causing a smooth,

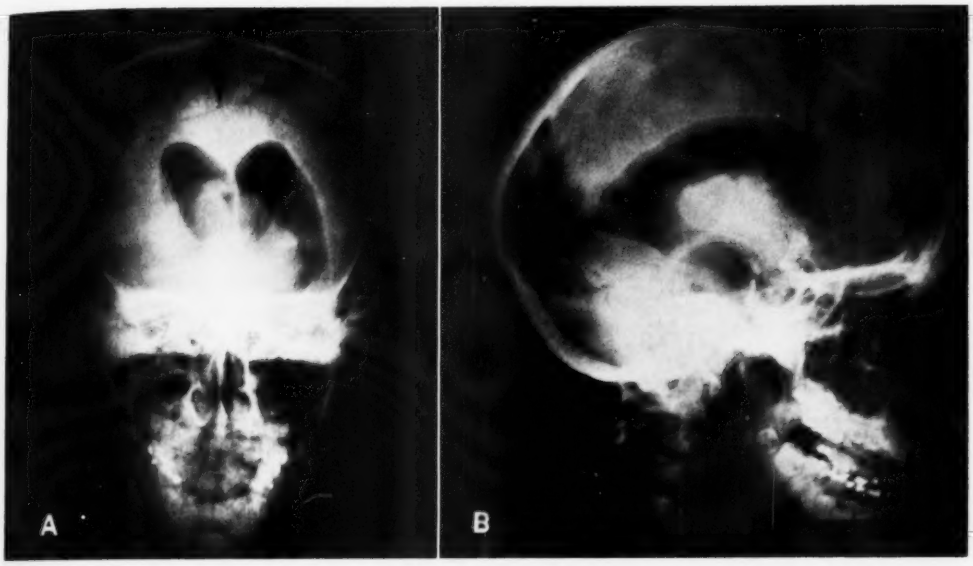

Fig. 5. Ventriculograms showing compression of one anterior horn of a lateral ventricle, elevation of the floor of this same ventricle, and obliteration of the third ventricle. Dilatation of the lateral ventricles has occurred.

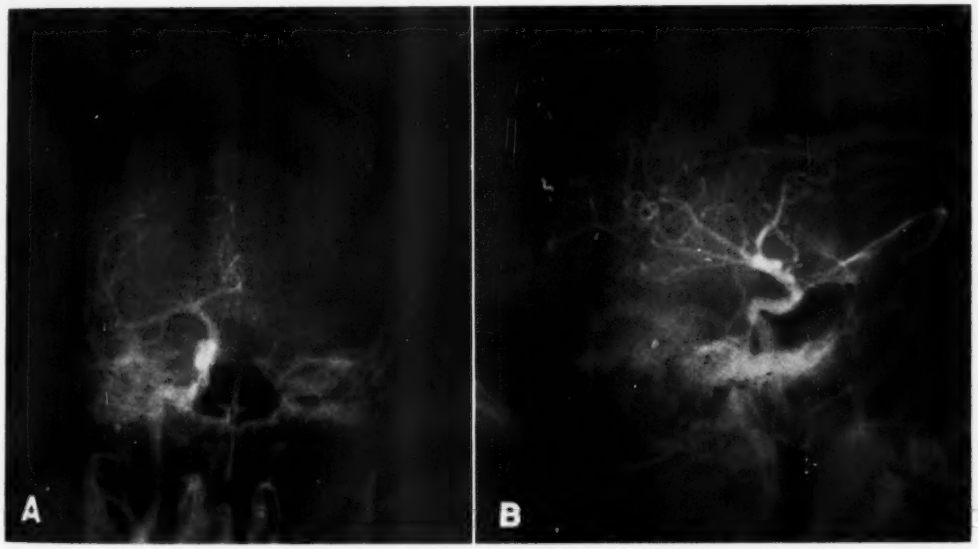

Fig. 6. A. Cerebral angiogram showing elevation of the internal carotid artery and the proximal portions of its two major branches.
B. Cerebral angiogram showing elevation of the internal carotid artery just before it divides and slight posterior displacement of the proximal portion of the anterior cerebral artery.

rounded defect in the anterior portion of this ventricle, as seen in a lateral projection. The lateral ventricles were enlarged in 27 patients, due to compression or narrowing of the foramen of Monro, preventing the escape of cerebrospinal fluid. Eccentric growth of the neoplasm produced variations in ventricular distortions; in several patients the mass lesion extended to one side of the midline. This caused dis-

placement of the third ventricle to one side and asymmetry of the anterior horns of the lateral ventricles. When the patients were examined by pneumoencephalography, it was found that the cisterna chiasmatica and the spaces adjacent to the tuberculum sellae were obliterated.

Only a few patients were investigated by carotid angiography. The internal carotid artery, when opacified, showed disappointingly little lateral displacement, for the neoplasms expand predominantly upward. Of 11 patients, 2 showed lateral deviation of the internal carotid artery siphon, and 7 slight upward deviation (Fig. 6). Widening of the carotid siphon is the result of the expanding mass displacing the artery upward, as well as the presence of hydrocephalus. The elevated origin of the anterior cerebral arteries is also due to these factors. In 2 patients, there were no abnormalities.

The last roentgen finding was a nonspecific spreading of the sutures in children when increased intracranial pressure was present.

Other pathological lesions simulate craniopharyngioma. Proved cases of cystic astrocytoma, chromophil pituitary adenoma, chordoma, and oligodendroglioma have deceived the radiologist at times. All these lesions were in the sella turcica or suprasellar region and produced calcific deposits identical with those found in craniopharyngioma.

SUMMARY

The roentgen features of craniopharyngiomas as seen in 62 patients were:

1. Increase in density of the sella turcica (7 patients)
2. Erosions of the sella (50 patients)
3. Calcification, linear and flocculent, (43 patients)
4. Mass lesions compressing the anterior aspect of the third ventricle and the anterior horns of the lateral ventricles
5. Slight elevation of the siphon of the internal carotid artery
6. Widening of the carotid siphon
7. Elevated origin of anterior cerebral artery.

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SUMMARIO IN INTERLINGUA

Aspectos Radiologic De Craniopharyngiomas

Es presentate un revista de 62 casos de craniopharyngioma, con attention special al constatationes roentgenologic. Istos include: (1) augmento de densitate del sella turcic (in 7 patientes); (2) erosion del sella turcic (in 50 patientes); (3) calcification in le forma de un fin contorno linear del peripheria del tumor o densitates flocculente (in 43 patientes); (4) compression del aspecto anterior del tertie ventriculo e del cornos anterior del ventriculos lateral; (5) leve elevation del siphon del interne arteria carotidic; (6) apertura del siphon carotidic; (7) origine alte del arteria cerebral anterior. Depositos calcific identic con illos trovate in craniopharyngioma pote esser producite per astrocytoma cystic, adenoma pituitari chromophilic, e oligodendroglioma in le sella turcic o in le region suprasellar.

Congenital Flatfoot Due to Talonavicular Dislocation (Vertical Talus)[1]

SAMUEL B. HAVESON, M.D.

CONGENITAL talonavicular dislocation is a distinct though infrequent cause of flatfoot. This anomaly may be unilateral or bilateral; it is occasionally associated with other localized or generalized malformations and has been found in two members of the same family (10). Osmond-Clarke (13) recently stated that he had observed only 5 cases during thirty years of orthopedic practice. A few orthopedic textbooks (5, 9, 10) contain a description of this deformity, but no information concerning it could be found in the English radiologic literature. This paper will describe the gross anatomical and functional disturbance of congenital talonavicular dislocation and report 4 cases illustrating the salient clinical and roentgenologic features of this anomaly.

The disturbance of anatomy of the hindfoot produced by the talonavicular dislocation is illustrated in Figure 1. Although the etiologic factors resulting in the anatomical derangement are not known with certainty, the following sequence of events may be assumed. The distal portions of the calcaneus and talus rotate toward the plantar surface, the talus rotating into a vertical position. The subtalar joint apparently remains intact, but the plane of this joint assumes a more vertical position than normally found (B, Fig. 1). Rotation of the distal talus and calcaneus toward the plantar surface results in medial rotation of the talus and eversion of the calcaneus at the subtalar joint (2, 4). The head of the talus is therefore directed medially and inferiorly. The vertical position of the talus allows only the posterior portion of its superior articular surface to articulate with the tibiofibular mortise (A, Fig. 1). A dislocation of the talonavicular joint occurs, resulting in an abnormal articulation of the navicular with the superior surface of the neck of the talus (C, Fig. 1) and widening of the calcaneocuboid joint (D, Fig. 1). Thus, a relative dorsiflexion of the forefoot occurs at the transverse tarsal joint. Eversion of the forefoot accompanies the dorsiflexion (12), and the normal longitudinal arch is obliterated or even reversed due to the prominence of the talar head on the plantar aspect. Marked abduction of the forefoot is primarily due to the valgus position of the calcaneus, although a minimal degree of abduction probably occurs as the forefoot

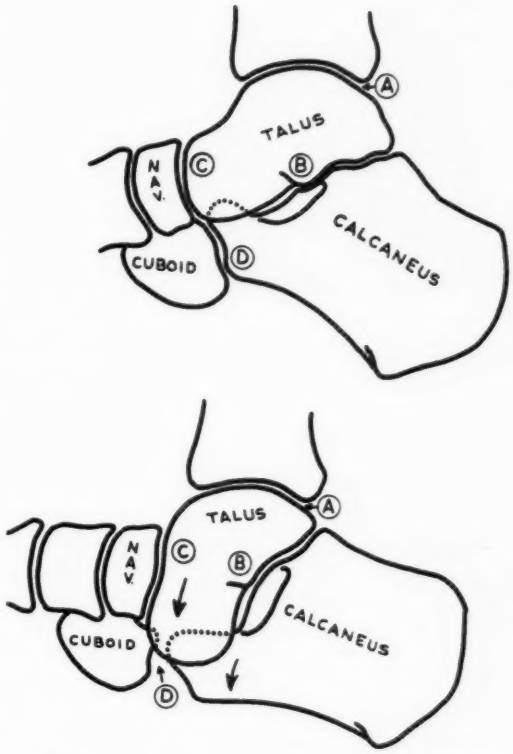


Fig. 1. Diagram illustrating relationship of bones in normal hindfoot, and in talonavicular dislocation. A. Ankle joint. B. Talonavicular articulation. C. Subtalar joint. D. Calcaneocuboid articulation.

[1] From the Department of Radiology, University of California School of Medicine, San Francisco, Calif. Accepted for publication in May 1958.

is dorsiflexed at the transverse tarsal joint (12).

Shortening of the Achilles tendon of the abnormal foot is a frequent finding (9). Whether this shortening is congenital or represents an adaptive process is not known. The short tendon may play the initial role in the production of the talonavicular dislocation by plantarflexing the hindfoot. This would then permit gradual dorsiflexion of the forefoot in the manner described above. Talonavicular dislocation has been described as a "reverse" clubfoot (9, 10), and as the most severe form of talipes calcaneovalgus (12). There seems, however, to be no similarity between talonavicular dislocation and clubfoot deformities.

At birth, the deformity of the foot may be sufficiently marked to attract the attention of the examining physician or parent. The forefoot is turned outward, there is a prominent bulge on the plantar surface at the midtarsal region, and severe dorsiflexion of the forefoot may be present. Restriction of motion at the ankle, subtalar, and midtarsal joints is present and becomes more pronounced as the foot matures. Weight-bearing increases the deformity, and walking may be delayed or troublesome as a result of abnormal foot dynamics.

The diagnosis in the older child and adult is easily made by roentgen examination. A lateral projection of the foot reveals the characteristic vertical talus, the articulation of the navicular with the superior surface of the neck of the talus, and rotation of the distal calcaneus toward the plantar surface (Figs. 1, 3, and 4). The calcaneocuboid separation is more striking in the younger patient, diminishing as adaptive changes occur in the maturing foot (Figs. 3 and 4). Medial displacement of the distal talus and abduction of the forefoot are demonstrated on the dorsoplantar projection (Fig. 2). The forces exerted on the navicular may result in decrease of its longitudinal diameter and irregularity of the articular surface opposing the talus (Figs. 2, 4). A wedge-shaped deformity of the navicular may eventually occur, with the apex of the wedge directed inferiorly. Medial displacement of the navicular in one adult patient was an unusual finding (Fig. 2). In the common hypermobile type of flatfoot, the navicular is displaced laterally with the calcaneus, cuboid, and metatarsals, as the talus rotates medially and downward.

Ossification of the navicular occurs in the second or third year of life (1). Diagnosis in the neonatal patient is therefore more difficult unless particular attention is paid to the position and relationships of the talus, calcaneus, and cuboid. Dorsiflexion of the forefoot and fulness of the soft tissues on the plantar aspect in the midtarsal region are additional signs (Fig. 3). Comparison of films of the affected foot with films of the opposite normal foot, or with available normal standards if the deformity is bilateral, will in most instances enable one to arrive at the proper interpretation.

CASE I (Fig. 2): M. B., a 22-year-old Negro female, was examined in the orthopedic out-patient clinic because of marked bilateral flatfoot deformity associated with minimal pain only after prolonged standing. Examination revealed rigid feet with flat longitudinal arches and tight heel cords. X-ray findings of vertical talus, "plantarflexed" calcaneus, abduction of the forefoot, and deformed medially displaced navicular were present bilaterally. Views of the subtalar joint revealed no evidence of talocalcaneal coalition.

CASE II (Fig. 3): C. W., an 8-week-old Negro male, was referred to the orthopedic clinic because of a marked deformity of the right foot present since birth. The foot was turned out and dorsiflexed. The family history was negative for congenital anomalies. Examination revealed dorsiflexion, calcaneovalgus, and abduction of the forefoot on the right. There was limitation of motion in all directions compared to the normal left foot. Roentgenograms demonstrated a vertical talus, plantar rotation of the distal calcaneus, and calcaneocuboid separation on the right. The left foot was normal radiologically. A plaster cast was applied, wedged at the appropriate place, and worn for approximately three months. When it was removed, there was concavity of the longitudinal arch due to moulding of the soft tissue, but no change in the relationship of the bony structures was evident.

CASE III (Fig. 4): L. W., a 4-year-old Negro male, was seen in the pediatric clinic because of a deformity of the right foot which had been present

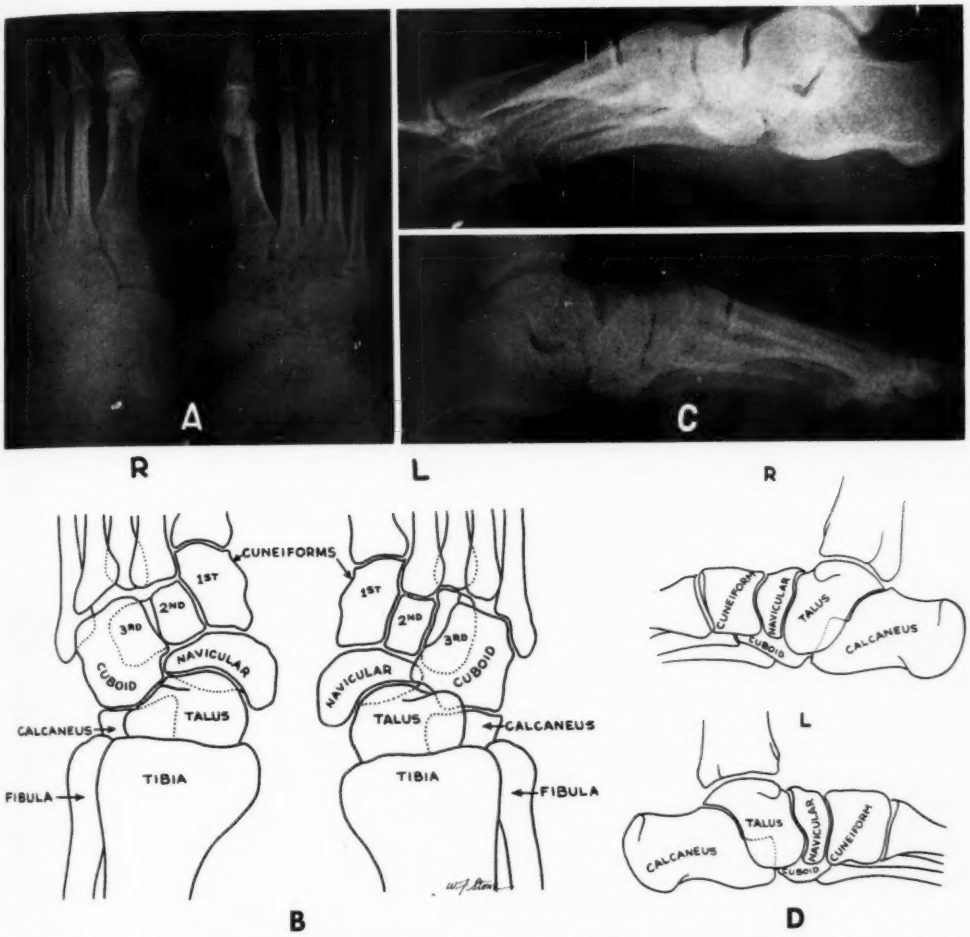


Fig. 2. Case I. A and B. Anteroposterior projection of both feet and tracing. The distal talus and navicular are medially displaced and the forefoot is abducted. The navicular is flattened in its medial portion. Similar findings bilaterally.

C and D. Lateral projection and tracing. The right foot is uppermost. The talar head is directed toward the plantar surface and the abnormal articulation of the navicular with the neck of the talus is demonstrated. The distal calcaneus is rotated toward the plantar surface and there is slight calcaneocuboid separation. Note the irregularity of the articular surface of the navicular opposing the neck of the talus and the wedge-shaped deformity of the navicular. Only the posterior portion of the superior articular surface of the talus articulates with the tibiofibular mortise.

since birth. Between three and five months of age, the patient wore a brace on the right foot, but no further treatment had been given. At the age of twelve months, he had learned to walk, but a limp had been noticeable since that time. Examination revealed a normal left foot and a marked flatfoot on the right, with typical roentgen findings of talonavicular dislocation. Conservative therapy was initiated and continued intermittently for a period of eighteen months. The deformity persisted, and fifteen months later a modified Osmond-Clarke procedure (see below) was carried out. Despite the operative intervention, the deformity persisted.

CASE IV (Fig. 5): G. H., a 3-year-old white male, was admitted to the hospital because of mental retardation and malnourishment. At birth the head was said to have been enlarged. The patient had difficulty in nursing. Examination revealed a deformed cranium, high arched palate, receding mandible, marked scoliosis, and deformed feet. The testicles were undescended. Exaggerated inner canthus folds were present and there was webbing of the fingers, toes, axillae, antecubital and popliteal fossae. Roentgen examination of the deformed rigid feet revealed bilateral talonavicular dislocation.

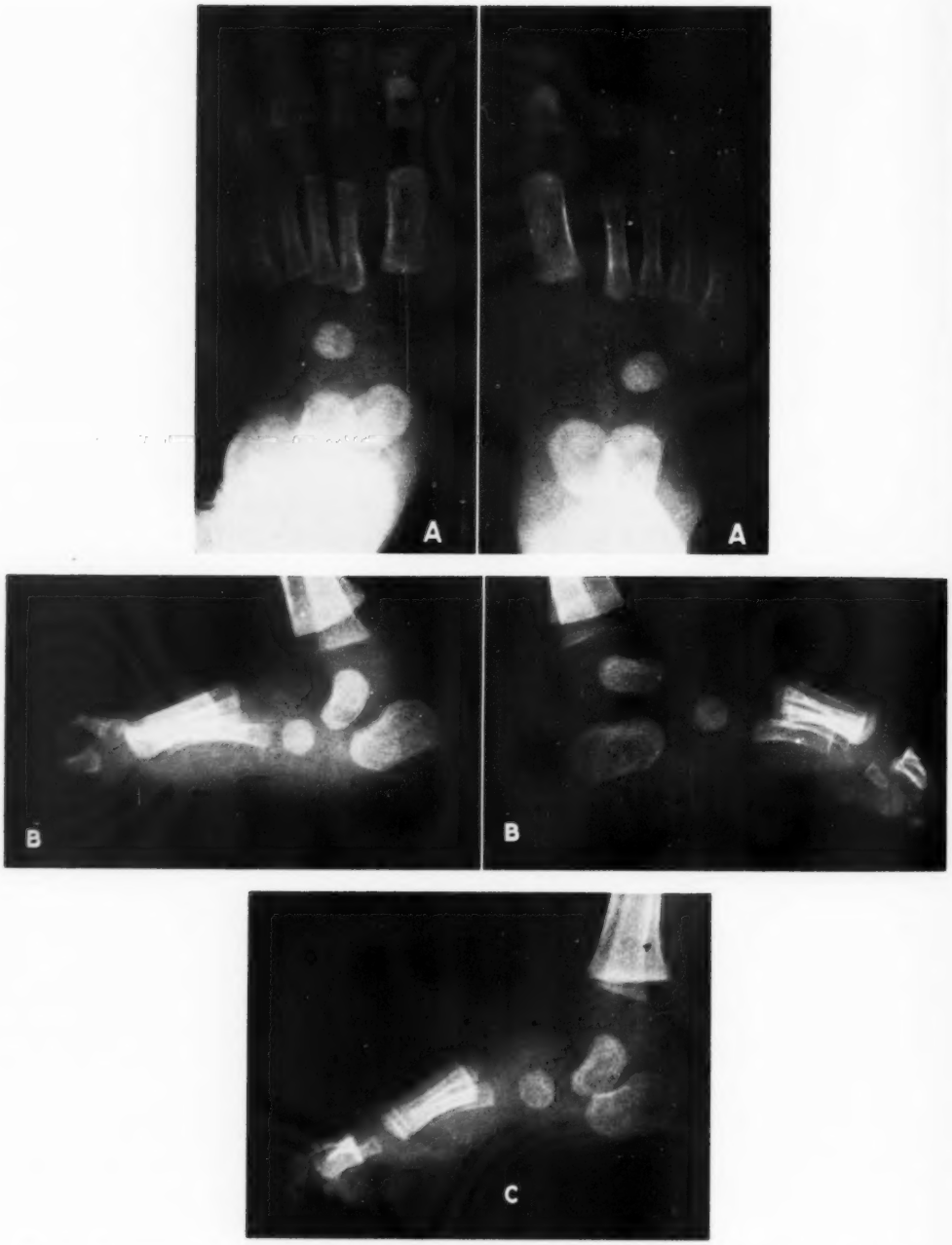
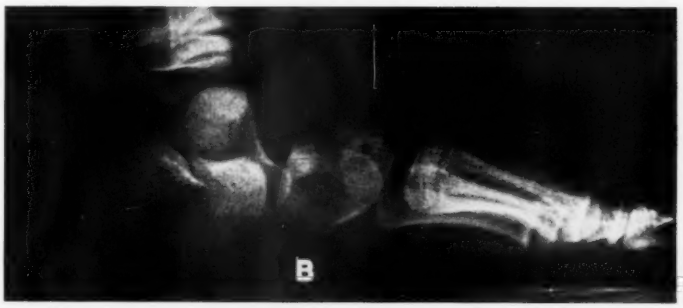


Fig. 3. Case II. A. Dorsoplantar projection of both feet. The navicular is not ossified. The head of the right talus is directed medially.

B. Lateral projection. Right foot to reader's left. The right foot is dorsiflexed at the ankle joint and the talus is vertical in position. Distal calcaneus is rotated toward the plantar surface and there is marked separation of calcaneus and cuboid. Note soft-tissue fulness on plantar aspect beneath talus and cuboid. The longitudinal arch is reversed. Compare with normal left foot.

C. Lateral projection of right foot after three months of wedging plaster casts. No change in position of talus or calcaneus.



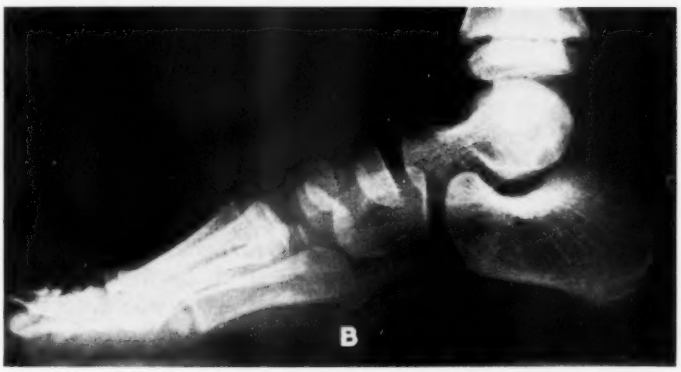


Fig. 4. Case III. A. Dorsoplantar projection. The right navicular is flattened and irregular. The talar head is directed medially. Abduction of right forefoot partially corrected by previous therapy. The left foot is normal.

B. Lateral projection. The longitudinal arch of the right foot (upper) is reversed. Talus is vertical and calcaneus is "plantarflexed." Articular surface of navicular opposing talar neck is irregular. Calcaneocuboid relationship is abnormal. Compare with normal left foot (lower).

Talonavicular dislocation is easily differentiated from other causes of flatfoot by roentgen examination. Rigid flatfoot is due to the presence of partial or complete talocalcaneal, calcaneonavicular, or cubonavicular synostoses (8, 15). Peroneal

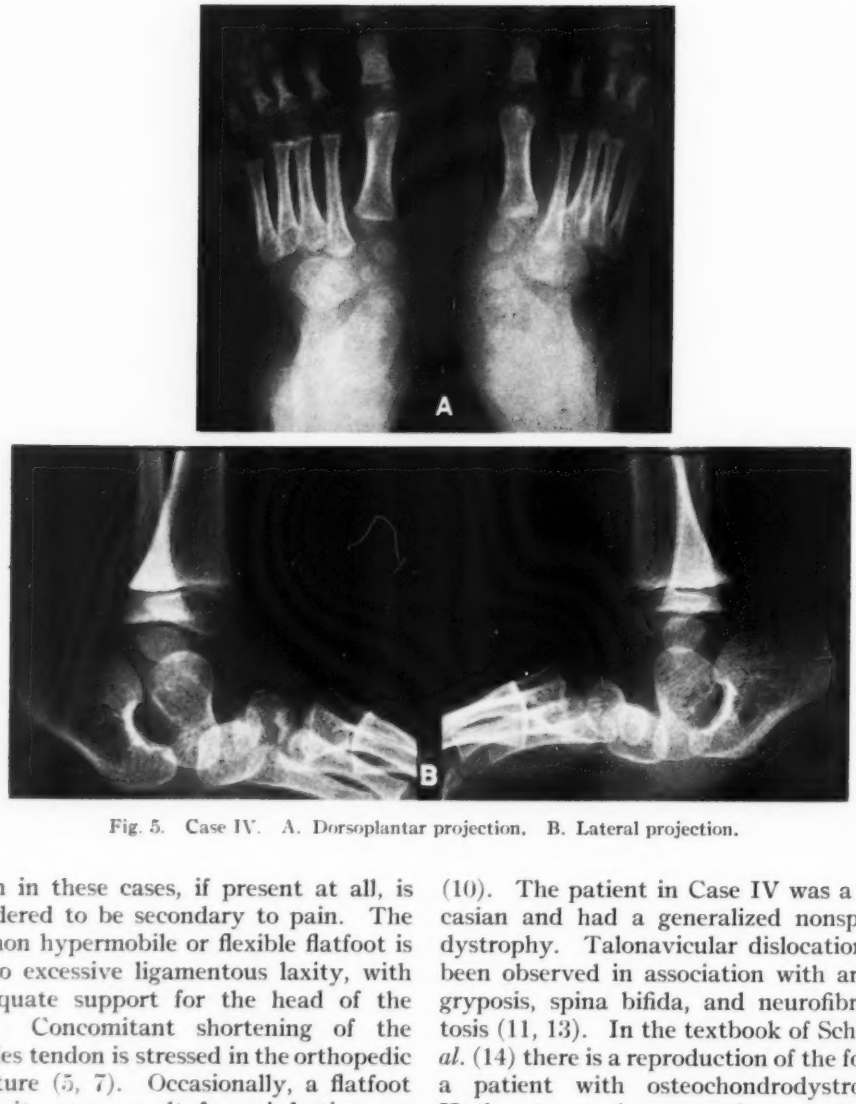


Fig. 5. Case IV. A. Dorsoplantar projection. B. Lateral projection.

spasm in these cases, if present at all, is considered to be secondary to pain. The common hypermobile or flexible flatfoot is due to excessive ligamentous laxity, with inadequate support for the head of the talus. Concomitant shortening of the Achilles tendon is stressed in the orthopedic literature (5, 7). Occasionally, a flatfoot deformity may result from infectious or traumatic arthritis, or paralysis due to neurologic disease.

It is of interest that 3 of the 4 patients discussed in this paper were Negroes. A high incidence of congenital abnormalities of the foot is said to be present in South African Bushmen and American Negroes (6). Race incidence has not been mentioned in previous reports of talonavicular dislocation, and 2 patients whose photographs were published appear light-skinned (10). The patient in Case IV was a Caucasian and had a generalized nonspecific dystrophy. Talonavicular dislocation has been observed in association with arthrogryposis, spina bifida, and neurofibromatosis (11, 13). In the textbook of Schinz *et al.* (14) there is a reproduction of the foot of a patient with osteochondrodystrophy, Hurler type, demonstrating a classical talonavicular dislocation. Kite (10) mentioned one patient with talonavicular dislocation of one foot and a clubfoot deformity of the other.

Treatment of the talonavicular dislocation is generally considered to be difficult. Recurrence of the deformity usually follows conservative therapy consisting of application of plaster casts and wedging. Occasionally, arthrodesis has been necessary in the presence of disabling symptoms (13).

Osmond-Clarke has described a new operation in which the peroneus brevis tendon is detached at the base of the fifth metatarsal, passed through the neck of the talus, and then sutured back on itself. Transplantation of the tendon is done after operative replacement of the talus, navicular, and calcaneus to their normal positions. The transplanted peroneus muscle provides an active force to hold the talus in a more nearly normal position. This procedure was performed in Case III without appreciably altering the deformity. Clinical results indicate need for further study of the treatment of talonavicular dislocation.

SUMMARY

The altered gross functional anatomy, and roentgenologic and clinical aspects of congenital talonavicular dislocation are discussed. Four cases are presented.

NOTE: I wish to express my appreciation to Doctor Donald B. Lucas, Assistant Professor of Orthopedics, University of California, School of Medicine, San Francisco, for his critical evaluation and helpful suggestions in the preparation of this manuscript.

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SUMMARIO IN INTERLINGUA

Congenite Pede Plan, Causate Per Dislocation Talonavicular (Talo Vertical)

Congenite dislocation talonavicular es un distincte ben que infrequente forma de pede plan. In iste deformitate le capite del talo es dirigite medial- e inferiormente, e solmente le portion posterior de su superficie articular superior es in articulation con le union tibiofibular. Il occurre un dislocation del articulation talonavicular, resultante in un articulation anormal del osso navicular con le superficie superior del cervice del talo e un allargamento del articulation calcaneocuboide. Assi un dorsiflexion relative del pede anterior occurre in le articulation tarsal transverse. Eversion del pede anterior accompania le dorsiflexion, e le normal arco longitudinal es oblitterate o mesmo revertite in consequentia del prominentia del capite talar al aspecto plantar.

A vices le deformitate es apparente al tempore del nascentia. In juveniles de etate plus avantiate, le diagnose es facile a facer per medios roentgenographic. Un projection lateral revela le characteristic talo vertical, le articulation del osso navicular con le superficie superior del cervice del talo, e le rotation del calcaneo distal verso le superficie plantar. Displaciamento medial del talo distal e abduction del pede anterior es demonstrate in le vista dorsoplantar.

Es reportate quatro casos.

Thrush Complicating Radiotherapy of the Mouth and Neck[1]

H. HARRISON EELKEMA, M.D., PAUL W. SCANLON, M.D., MALCOLM Y. COLBY, JR., M.D., AND JOHN A. ULRICH, Ph.D.

MEMBRANOUS lesions which often complicate intensive radiation therapy of malignant lesions of the head and neck, we believe, have been generally assumed to be a direct effect of radiant energy. The possibility that infection with *Candida albicans* may be important in the formation of these lesions, either as a causative or a complicating factor, recently has been brought to our attention.

Severe membranous lesions developed in the mouth of a 46-year-old woman while she was receiving x-ray therapy for nasopharyngeal cancer. Dr. C. F. Lake of the Section of Otolaryngology and Rhinology (Mayo Clinic) observed that the lesions resembled thrush, and culture of a portion of the membrane showed *Candida albicans*. This case stimulated an investigation into the possibility that membranous lesions found under similar conditions might be superimposed thrush.

STUDY OF CASES

Cultures or direct smears, or both, were made of the membranes of 7 patients who exhibited this complication of radiation therapy of lesions of the head and neck. At the time of culture the lesions of all patients were similar, appearing as gray-white friable membranes superimposed on a base of edematous, inflamed mucosa (Fig. 1). Bleeding was not noted. The findings in these 7 cases are summarized in the accompanying table. A positive culture for *C. albicans* was obtained in every instance. After the specimen was cultured on penicillin-streptomycin blood agar and chloromycetin agar, identification of the yeast isolated was completed with the use of Benham's cornmeal agar. In the 4 cases in which direct examination of the smear was done, the organism was found growing in the filamentous form in the membrane (Fig. 2). Demonstration of the filamentous phase of growth in tissue is generally considered evidence of actual invasion. We think, therefore, that this indicates that the *C. albicans* was not existing merely as a saprophyte.

Fig. 1. Typical lesion of thrush.

Cultures from the mouth were obtained also in 3 additional cases in which radiomucositis was well developed but confluent membrane formation had not occurred. The cultures in these 3 cases were negative for *C. albicans*.

ETIOLOGIC ASPECTS

Candida albicans is a yeast commonly present in the mouth as a saprophyte. Pathologic overgrowth of this organism results in the clinical infection known as thrush or moniliasis. The disease in adults has been uncommon but has become more prevalent since the development of antibiotics. An imbalance of the normal mouth and throat flora caused by antibiotic therapy, with subsequent overgrowth of *C. albicans* can be considered the chief reason for moniliasis in the adult mouth. Poor general nutrition, local in-

[1] From the Mayo Foundation (H. H. E., Fellow in Radiology) and the Sections of Therapeutic Radiology (P.W.S. and M.Y.C.) and Bacteriology (J.A.U.) of the Mayo Clinic, Rochester, Minn. The Mayo Foundation is a part of the Graduate School of the University of Minnesota.

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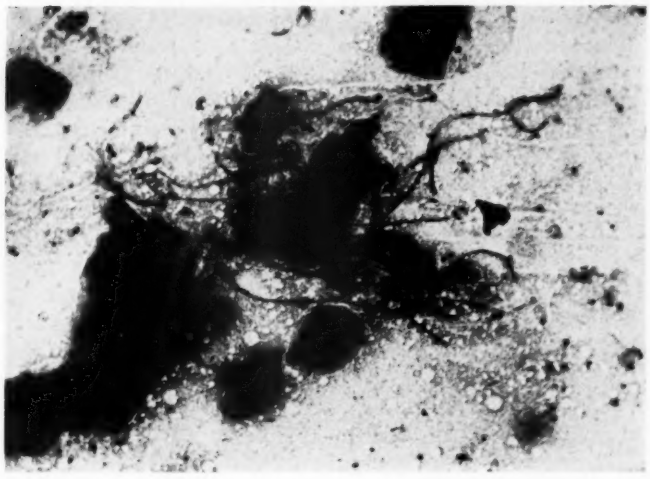

Fig. 2. Direct smear of membranous material showing filamentous forms growing in the tissue. Yeast phase of Monilia also present. Gram stain. × 225.

SUMMARY OF DATA ON PATIENTS EXHIBITING THRUSH AS A COMPLICATION OF RADIATION THERAPY

Case	Age (in years) and sex	Diagnosis	Treatment	Material cultured	Culture for C. albicans	Tissue smear for C. albicans
1	46F	Nasopharyngeal carcinoma	250-kv, high dosage	Membrane	Positive	Not made
2	36F	Cylindroma of right parotid gland	Co^{60}, high dosage	Membrane	Positive	Not made
3	70F	Cylindroma of right submaxillary gland	Co^{60}, high dosage	Membrane	Positive	Not made
4	65M	Lymphosarcoma of right antrum	Co^{60}, medium dosage	Membrane	Positive	Positive
5	41M	Carcinoma of right tonsil	Co^{60}, high dosage	Membrane	Positive	Positive
6	76M	Carcinoma of left cheek	Co^{60}, high dosage	Membrane	Positive	Positive
7	58M	Carcinoma of base of tongue	Co^{60}, high dosage	Membrane	Positive	Positive

jury, and faulty oral hygiene account for some cases.

The insult to the mucous membranes by radiation, plus the debilitated condition of the occasional patient treated with roentgen rays, also appears to be adequate reason for the occurrence of thrush. Salivary secretion is reduced sharply in quantity (1) and quality (2) by irradiation of the salivary glands. Changes in salivary secretions could possibly upset the normal balance of mouth flora.

Killian (3), in 1920, described the case of a child who was treated with radiation for tuberculosis of the salivary glands. The throat had a diphtheria-like appearance, but no diphtheria bacilli could be demonstrated. In addition, the process had been present for two weeks. Killian concluded that radiation was responsible for the unusual form of mucositis seen. It is entirely possible that the lesion he described was actually thrush.

Coutard (4), in 1922, described in detail the sequence of radiomucositis. He remarked that the initial redness and pain were followed by the appearance of nonconfluent vesicles, which were rapidly

succeeded by large patches similar to those of diphtheria. He also added that several of the symptoms, especially the diphtheria-like patches and pain, were due at least in part to secondary infection, hardly to be avoided in the mouth.

Oughterson and Warren (5) demonstrated the mycelia of thrush by microscopic section of the pharynx in a person dying after exposure to the atomic bomb at Hiroshima. They stated that the occurrence of thrush probably reflected the poor state of general health of the individual. To the best of our knowledge, however, there has been little in the radiologic literature which would tend to implicate thrush as a direct causative or complicating factor in the membranous formation so commonly seen as a late stage of radiomucositis.

The demonstration that some of the so-called classical changes of radiation mucositis are due to secondary infection is not surprising. This had been surmised by Coutard and doubtless by others. That *C. albicans* is one of the pathogens is important, for these infections are refractory to the commonly used oral antiseptics. It is interesting to speculate whether the white, membranous lesions of radiation-induced proctitis are not also caused or complicated by pathologic overgrowth of *C. albicans*.

TREATMENT FOR THRUSH

At present there are many methods of treatment of oral thrush, none of which is completely satisfactory. In the past, oral lesions have been treated with alkaline mouth washes, gentian violet or sodium caprylate. Recently Wright, Graham, and Sternberg (6) have reported on the use of nystatin. Of their 42 patients with oral moniliasis, 19 gave an excellent response to the drug, 22 were classified as having a good response, and 1 as having a fair response. In view of their results it seems probable that nystatin is the best drug for treatment of oral moniliasis now available.

Our present treatment of oral thrush consists of the administration of 1 to 2 c.c. of nystatin (Mycostatin, oral suspension, 100,000 units in 1 c.c.) placed directly in the mouth and held as long as possible before swallowing. This is repeated four times daily. Although there has been no dramatic change in the discomfort of patients with severe degrees of radiomucositis, it seems to us reasonable that elimination or diminution of concurrent thrush could serve to lessen the duration of postirradiation morbidity and in a relative sense add to the patient's comfort and sense of well-being.

SUMMARY

Cultures or direct smears, or both, were made of membranous lesions of the mouth developing in 7 patients receiving roentgen or cobalt-60 therapy for disease of the head or neck. All cultures were positive for *C. albicans*, and in the 4 cases in which direct examination of the smear was done the organism was found growing in the filamentous form in the membrane.

Damage to tissue owing to irradiation plus the possible effect on the normal mouth flora caused by changes in the secretions of the salivary glands is considered responsible, at least in part, for the pathologic overgrowth of *C. albicans*. The secondary infection thus produced is refractory to the commonly used oral antiseptics. Nystatin is the best drug available at present for this complication of irradiation therapy.

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SUMMARIO IN INTERLINGUA

Aphthas Como Complication De Therapia De Radiation Del Bucca O Del Collo

Culturas o frottis directe o ambes esseva facite ab lesiones membranose del bucca que se habeva disveloppate in 7 patientes recipiente therapia Roentgen o therapia a cobalt-60 in le tractamento de morbos del capite o del collo. Omne le culturas esseva positive pro *Candida albicans*, e in le 4 casos in que directe examines de frottis esseva effectuate, le organismo esseva trovate crescente in su forma filamentose in le membrana.

Es opinate que irradiation produce alterationes in le secretion del glandulas salivari. Assi le normal balancia del flora oral es disturbate, con le resultato de un crescentia excessive de *Candida albicans*, le qual es communmente presente in le bucca como saprophyto. Le infection secundari assi producite es refractori al antisepticos oral in uso commun. Nystatina pare esser le melior droga currentemente disponibile pro le tractamento de iste complication del therapia irradiational.

Excavation of Metastatic Nodules in the Lung

Roentgenographic Considerations[1]

FREDERICK W. DECK, M.D., and ROBERT S. SHERMAN, M.D.

MOST PULMONARY metastases are readily detectable by the radiologist and at the same time can usually be identified as such. Approximately 60 per cent of the secondary deposits found postmortem are said to be radiographically visible (1). Minor (2), in a study of 5,720 neoplasms, found 314 in which pulmonary metastases were demonstrated radiographically. He classified these deposits on the basis of their radiographic appearance as nodular, infiltrative, lymphangitic, miliary, and massive consolidative types. There is still much confusion in the literature about the classification of metastatic pulmonary lesions but Minor's plan appears to us to be as basic and simple as possible. While there is often some overlapping, and mixed types do occur, in any particular case the classification is made on the basis of the predominant aspect.

Certain metastatic lesions present features of special interest to the radiologist. The presence of calcification in the lung metastases of some osteogenic sarcomas and chondrosarcomas lends specificity to these deposits. In a previous publication a study was made of spontaneous pneumothorax due to metastatic disease (3). It was noted that this is usually associated with sarcoma rather than carcinoma. The single nodular metastatic deposit may likewise be of particular interest, inasmuch as extirpation of this one focus may delay dissemination of the malignant process. In these cases, however, it is usually impossible roentgenographically to differentiate the metastatic nodule from a primary lung neoplasm.

In the present study our interest is in excavation of nodular pulmonary metastases. This is a relatively uncommon phenomenon but one of practical importance to the diagnostic roentgenologist. Farrell (4) states that "multiple metastatic foci rarely break down." He describes 1 case of sarcoma of undetermined origin metastatic to the lungs with roentgenographic and necropsy proof of excavation in some of the nodules. Minor reports 4 cases with excavation, for only 1 of which the primary lesion was documented, a carcinoma of the bladder. Salzman *et al.* (5) reported 2 cases, metastatic from seminoma of the testes and carcinoma of the pancreas, respectively. Katzev and Bass (6) document the primary in their case as carcinoma of the large bowel. The case described by Meyers and Sala (7) is interesting in that the lesion was in the left upper lobe bronchus with nodular spread to both right and left lungs and cavitation. Lichtenstein (8) mentions a sclerosing osteogenic sarcoma with massive pulmonary metastasis and excavation. Dickson and Smitham (9) report 2 and Efskind and Wexels (10) report 3 cases of Hodgkin's disease of the lung with cavitation.

Our material consists of 21 cases, each with one or more chest films showing clear-cut evidence of cavitation. A number of cases were excluded because unequivocal evidence of cavitation was not present radiographically. In all of the series there was histologic proof of the primary neoplasm, and in most instances histologic proof of the metastasis as well. This was obtained either at necropsy or thoracotomy except for 2 cases in which cytologic proof was taken as confirmation of the diagnosis of the lung lesion. All patients had a clinical course and x-ray studies in keeping with the diagnosis of pulmonary metastases.

In the published cases, excavation in

[1] From the Department of X-Ray Diagnosis, Memorial Center for Cancer and Allied Diseases, New York, N. Y. Presented before the James Ewing Society, April 19, 1958. Accepted for publication in May 1958.

nodular pulmonary metastases has been described as central in location, with discharge of contents, presumably by evacuation through the nearby bronchus. In their case of primary Ewing's sarcoma of the femur Dolgoff and Hansen (11) actually identified the contents of such a nodule expectorated *via* the bronchus and studied histologically. Rarely one encounters bronchial obstruction due to a metastatic deposit with formation of a lung abscess in the atelectatic lung, but this has not been described to our knowledge. Wigh and Gilmore (12), in their discussion of solitary pulmonary necrosis, do not mention this phenomenon.

The cavitation showed no special features in the published cases and the same is true of our series. There was no constancy in size or shape of the cavities, which ranged from 4 mm. to 5 cm. in diameter. The thickness of the walls varied from 1 mm. to 7 mm. and both smooth and irregular internal contours were seen. The number of metastatic foci ranged from 1 to more than 50 distinct nodular densities, but most often cavitation was present in only a few nodules, the remainder having the usual homogeneous texture.

Difficulty in differential diagnosis was encountered in 2 cases. One with a single cavity was thought to be a primary neoplasm of the lung or a large lung abscess. This proved to be a thyroid tumor metastasis with peripheral abscess formation due to bronchial obstruction, as noted above. In the other, several small cavities were demonstrated and a presumptive diagnosis of tuberculosis or fungous disease was made.

Sometimes, where radiation was given to metastatic nodules, there was ensuing cavitation, but this occurred also in the other cases, without local therapy.

We have been especially interested in Wilms' tumor nodules in the chest, since it has been said that this tumor tends to excavate more readily than any other. Twenty-eight cases from our files for the past five years, 1953–57, inclusive, were studied. Most of these patients had received x-ray therapy to the chest. The clinical course, treatment, and roentgenograms were reviewed. Each had adequate chest film coverage for a period of at least one year. In every instance there was histologic proof of the primary lesion. Four patients followed from two to five years showed no metastasis. One showed definite cavitation, which disappeared and reappeared. This patient has been followed for four years and is still alive. One other showed equivocal changes, possibly indicating a small necrotic area in one of the numerous nodules. In none of the remaining 22 cases was there evidence of cavitation at any time.

Fig. 1. Case I: Carcinoma of thyroid with metastasis to peribronchial area, producing stenosis and distal abscess. Tracheal deviation denotes the thyroid mass.

The results indicate no definite correlation between a primary Wilms' tumor and excavation in its pulmonary metastatic foci. Nor did any such correlation appear to exist in the other cases in our series.

The following histories have been selected to demonstrate significant features pertaining to liquefaction of metastases in the lungs.

CASE I (Fig. 1): M. M., a 66-year-old white male, entered the hospital with hemoptysis of one month duration. Roentgenograms showed a solid solitary lesion in the left upper lobe. During hospitalization, fever, chills, and leukocytosis developed

Fig. 2. Case II: Multiple metastases with excavation and fluid levels. Primary carcinoma of bladder.

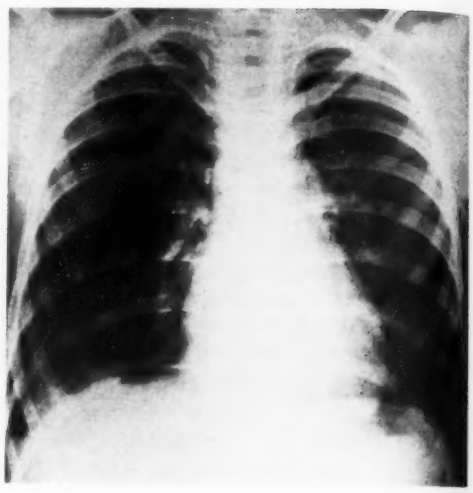
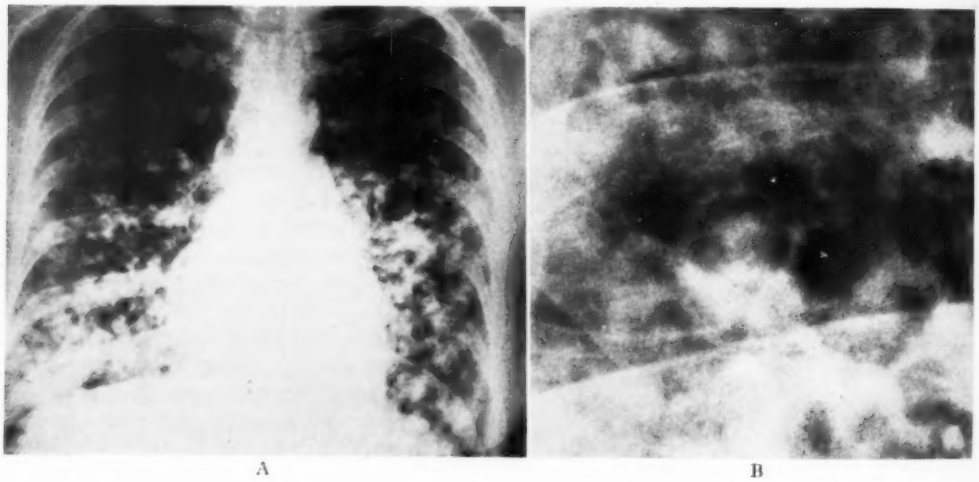


Fig. 3. Case III: Several deposits with excavation. Primary neoplasm was Wilms' tumor.



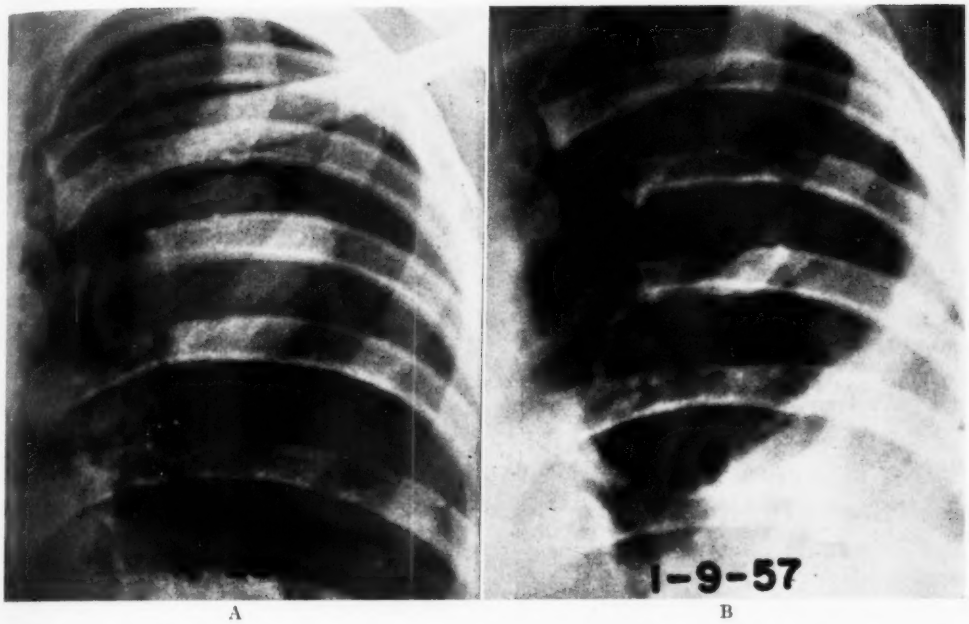
A B

Fig. 4. A. Primary lung cancer, terminal bronchiolar type, with many metastatic deposits showing excavation. This was thought to be tuberculosis on the first roentgen examination. B. Detail of the lung deposits.

and cavitation with a fluid-air level and enlargement of the lung mass were demonstrable. The report on Papanicolaou studies was Class II. Physical examination revealed an enlarged, hard left lobe of the thyroid. Scalene and supraclavicular node biopsies showed no evidence of tumor. The mass appeared to get smaller with chemotherapy.

Thoracotomy disclosed a mass encircling the left upper lobe bronchus, with distal abscess cavity. The pathological report was "secondary carcinoma, compatible with metastasis from carcinoma of the thyroid, and chronic lung abscess." Subsequent thyroidectomy showed a carcinoma.

CASE II (Fig. 2): V. P., a 54-year-old white female, complained of hematuria in June 1950. She was treated by partial cystectomy and repeated fulgurations. On Feb. 28, 1951, fulguration was again done and the biopsy report was now epidermoid carcinoma. Total cystectomy was performed on March 19, 1951. On Sept. 16, 1952, the chest film showed pulmonary metastases and on March 16, 1954, there was an increase in size and number of nodules, with liquefaction. The patient had no x-ray therapy to the chest but did receive adequate irradiation to the pelvis for recurrence of the bladder tumor.



A B

Fig. 5. A. Metastasis from an osteogenic sarcoma. B. Appearance five weeks later, after radiotherapy.

CASE III (Fig. 3): N. L. R., a 7-year-old girl, had hematuria, a mass in the left upper quadrant, and absence of function in the left kidney on pyelographic study. A nephrectomy was done Nov. 16, 1948, and the pathologist reported "Wilms' tumor." The patient improved, but metastases were confirmed by chest films Dec. 17, 1948. She was well until Nov. 1, 1949, when a nonproductive cough and chest pain developed. HN2 and x-ray therapy were given in January and April 1950, to a total of approximately 3,000 r in air to the anterior and posterior chest with 1,000-kv apparatus. Chest films revealed that the metastases decreased after the first treatment but had increased in size by March 1950. Excavation was noted radiographically in May 1950, associated with pneumonitis and pneumothorax. The patient died on June 25, 1950.

At autopsy both lungs were rubbery, firm, and red, and both contained tumor nodules, some firm and others soft with necrotic centers. The pathology report was: "Wilms' tumor with nodular metastases to lungs, some showing excavation, and radiation pneumonitis, severe."

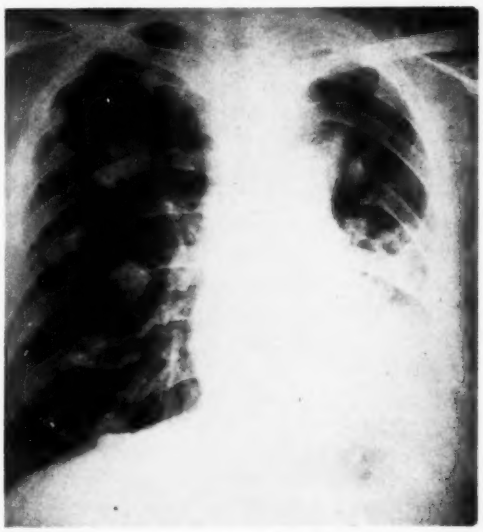


Fig. 6. Lung carcinoma on left, with metastases to lungs. Several deposits show excavation.

SUMMARY

1. Twenty-one cases of cancer metastases to the lungs with excavation were studied radiologically. The primary tumors were from most of the common sites, and were carcinomas or sarcomas.

2. A knowledge of the phenomenon of liquefaction of metastases is necessary so that the x-ray diagnostician may arrive at the correct diagnosis.

3. There is no specific roentgen appearance associated with excavation in metastatic nodules.

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SUMMARIO IN INTERLINGUA

Excavation De Nodulos Metastatic In Le Pulmones: Consideratione Roentgenographic

Es reportate un serie de 21 casos de metastatic tumores pulmonar in que cavitation es clarmente evidente. Le crescentias primari representava le majoritate del commun sitos de tumores, e tanto carcinomas como etiam sarcomas esseva includite

Le cavitation monstrava nulle specific aspectos roentgenologic, e nulle correlation con le lesion primari esseva notate. Le cavitates variava in diametro inter 4 mm e 5 cm. Le spissitate del parietes esseva inter 1 e 7 mm. Le contorno esseva lisie in certe casos e irregular in alteres. Le numero del focos metastatic variava ab un patiente al altere, sed usualmente non plus que un micre numero de noduios esseva excavate.

Un studio special esseva interprendite relative a metastases pulmonar ab tumores de Wilms, proque on ha asserite que le tendentia de producer cavitation es specialmente pronunciate in tal casos. Iste opinion non esseva confirmate.

Familiaritate con le phenomeno del excavation de metastases es importante a fin que le radiologo pote arrivar a un diagnose correcte.

Carotid Angiography in the Localisation of Supratentorial Neoplasms and Hamartomata[1]

PAUL F. J. NEW, M.B., B.S., F.F.R.[2]

THE HIGH ACCURACY of carotid angiography in demonstrating such vascular lesions as intracranial aneurysms, arteriovenous malformations, subdural haematomata, and the like, has been well established. The large majority now agree that cerebral angiography is the method of choice in the diagnosis of these vascular lesions. The place of carotid angiography in the diagnosis and localisation of supratentorial neoplasms is not so well established, and there is much difference of opinion concerning the relative merits of ventriculography, pneumoencephalography, and carotid angiography.

The following figures are taken from an investigation by Hodges and Holt (1) into the relative reliability of different radiological methods in localisation of brain tumours.

Encephalography (technique not recorded)	48 cases
Accuracy	60.5%
Ventriculography	447 cases
Accuracy	86.4%
Angiography	197 cases
Accuracy	72.0%

As is apparent, ventriculography was used in a high proportion of cases. Cerebral angiography is stated to have an accuracy of 72 per cent, against an accuracy of 60.5 per cent for encephalography, the definition of accuracy as used in this review being a localisation sufficient to indicate correctly the site and size of bone flap adequate for approach to the tumour. It is very doubtful, however, if radiologists and neurological surgeons should be satisfied with this criterion of accuracy, as it ignores the question of correct assessment of the extension in depth of a lesion.

A second tabulation illustrates the findings of an investigation into the relative accuracy of pneumography and angiography in the diagnosis of space-occupying lesions, conducted by Martin and Webster (2).

Encephalography	82 cases
Accuracy	36%
13 diagnostic failures in supratentorial lesions	
7 diagnostic failures in infratentorial lesions	
Ventriculography	96 cases
Accuracy	90%
4 diagnostic failures	
Angiography	57 cases
Accuracy	57%

Again, a high percentage of cases was submitted to ventriculography. Encephalography was found to have an accuracy of 36 per cent, but there were 20 diagnostic failures in 90 encephalograms. Since encephalography was performed by massive replacement of cerebrospinal fluid by air (100 to 150 c.c. exchange), this high percentage of diagnostic failures is perhaps not surprising. This also affects the estimate of accuracy of encephalography. It is noted, too, that 17 of the 82 cases examined by encephalography in this series were cases of subdural haematoma, for the investigation of which encephalography is hardly the method of choice. Only half of the subdural haematomata were localised by angiography, a remarkably low figure.

It is apparent from the above surveys that the methods of selection of cases for the three procedures, encephalography, ventriculography, and carotid angiography, left something to be desired and also that the technique of encephalography, in one series at least, was of debatable value.

We have found, by careful selection of cases for each of these three procedures and by careful elaboration of technique, including particularly a controlled fractional air injection of the Lindgren type for encephalography, that ventriculography is

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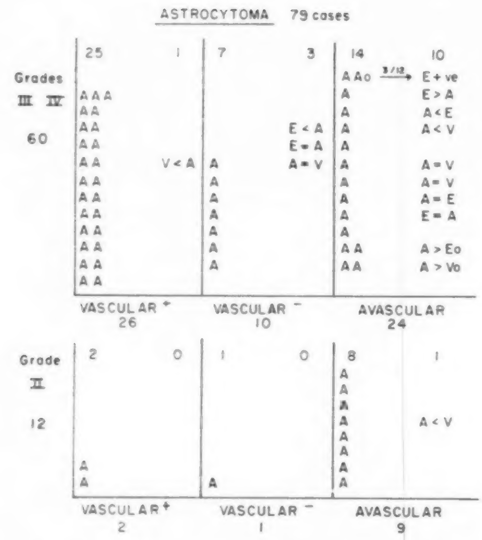

Fig. 1. Astrocytoma: Grades II, III, and IV. In this and the following figures A indicates angiography, E encephalography, V ventriculography.

A = E. Angiography employed first, then encephalography, both of equal value in *localisation*.
V > A. Ventriculography first employed, then angiography. Ventriculography was of greater value in localisation.
V_0 and E_0. V and E of little value in localisation, due to partial or complete technical failure.

required in very few cases of intracranial space-occupying lesion, whether supratentorial or infratentorial. We have also found that encephalography and angiography, on the criteria used by Hodges and Holt, are capable of an accuracy of over 90 per cent.

The substance of this paper is concerned with the accuracy of carotid angiography in the localisation of certain supratentorial neoplasms. It is apparent that some supratentorial neoplasms are not suitable for investigation by this means in the first instance, and these are excluded from our survey. Similarly, with the material available, only the commoner supratentorial tumours are represented in sufficient numbers to allow for a satisfactory appraisal of the accuracy of carotid angiography in their localisation and diagnosis.

In general, the midline basal tumors, unless suspected to be of a vascular nature, *e.g.*, large aneurysms presenting clinically as masses, vascular meningiomata, and arteriovenous malformations, are not as satisfactorily localised by angiography as by encephalography. In only a small percentage of these tumours will ventriculography be necessary or indeed as suitable as encephalography. Thus, pituitary tumours extending beyond the sella, gliomata of the optic chiasm and nerves, craniopharyngiomata, and the like, are not examined in the first instance by cerebral angiography. It is true that, in some cases, following localisation of such a mass by pneumography, angiography may be performed in an attempt to demonstrate the pathology and the degree of involvement of the major vessels at the base of the brain, to give warning to the neurological surgeon of possible difficulties in extraction of the mass. Our investigation is limited to the following commoner forms of supratentorial neoplasms and hamartomata: all forms of gliomata of the cerebral hemispheres, meningiomata, metastases, and arteriovenous malformations. These lesions constitute the large bulk of the supratentorial neoplasms and hamartomata presenting for investigation.

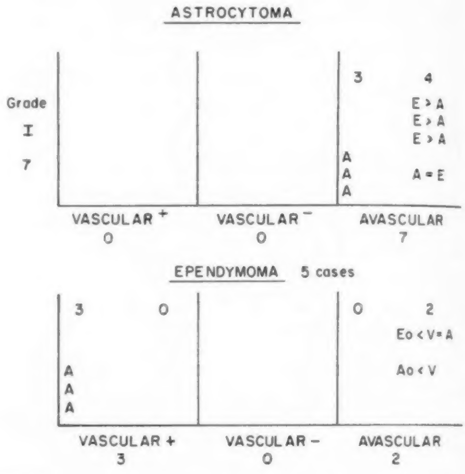

Fig. 2. Astrocytoma, Grade I and ependymoma. See Figure 1 for explanatory note.

The material comprises 131 supratentorial neoplasms and arteriovenous mal-

formations investigated and verified in the six years from 1952 to 1957 inclusive, out of a total of 213 intracranial neoplasms and hamartomata fully investigated in this period. The 131 cases, which com-

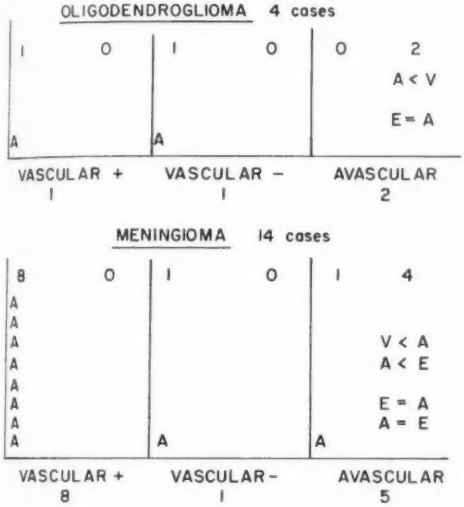

Fig. 3. Oligodendroglioma and meningioma. See Figure 1 for explanatory note.

prised 72.1 per cent of the supratentorial lesions, included:

Gliomata		88 cases (48.4%)
Astrocytoma (Grades I to IV)	79	
Ependymoma	5	
Oligodendroglioma	4	
Meningiomata		14 cases (7.7%)
Metastases		11 cases (6.0%)
Arteriovenous malformations		18 cases (10%)
TOTAL		131 cases (72.1%)

It will be seen that the surveyed group of neoplasms and malformations constitutes 62 per cent of all the intracranial neoplasms and hamartomata and some 72 per cent of the total supratentorial neoplasms and hamartomata.

The remaining 28 per cent of supratentorial neoplasms and hamartomata, such as craniopharyngiomata, suprasellar extensions of chromophobe adenomata of the pituitary, optic gliomata, and other miscellaneous avascular lesions of the midline basal areas, are excluded from the series,

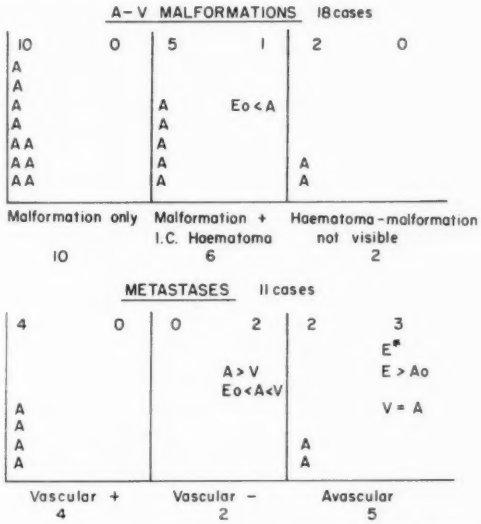

Fig. 4. Arteriovenous malformations and metastases. The single E marked by an asterisk refers to the only case in the series (multiple metastases) examined by pneumography alone. See Figure 1 for explanatory note.

as we have come to the conclusion, after trials, that these lesions are better localised by pneumography, as has been stated. Similarly, the more uncommon neoplasms, as for example teratoma, chordoma, and the like, were not seen in sufficient numbers to justify an attempt at assessment of the value of carotid angiography in their diagnosis.

The lesions in the surveyed group are listed. In general, the proportional representation of the different lesions conforms to that found in other published series. The frequency of utilisation of the three special methods of radiological investigation in the diagnosis and localisation of the 131 cases was as follows:

Angiography	98
Angiography and encephalography	18
Angiography and ventriculography	12
Angiography, encephalography, and ventriculography	2
Ventriculography	0
Encephalography	1
Total examined by angiography	130
Total examined by encephalography	21
Total examined by ventriculography	14
Total investigations in 131 cases	165

Carotid angiography was employed in all but one of these cases and pneumography (encephalography and/or ventriculography) was performed in only 35 cases.

As a general rule, patients suspected of harbouring neoplasms within the above pathological groups were subjected first to unilateral or bilateral carotid angiography. Where, in the opinion of the radiologist and surgeon, this did not provide sufficient localisation, the patient was further investigated by encephalography or ventriculography. Choice of initial and subsequent procedures was made by radiologist and neurosurgeon in consultation or by the radiologist alone. The large majority of the angiographic studies in this centre are performed by the radiologist.

Figures 1 to 4 illustrate the cases under the pathological diagnosis obtained by biopsy or postmortem, with subdivisions according to the degree of vascularity as determined by angiography, *vascular* + indicating that numerous tumour blood vessels were demonstrated and that these occupied the greater portion of the volume of the tumour and *vascular* − indicating that sufficient tumour blood vessels were visible to make a diagnosis of neoplasm beyond reasonable doubt, but that these occupied a relatively minor proportion of the volume of the tumour. The final division represents those cases in which no convincing tumour circulation could be identified.

As would be expected, the large bulk of the vascular tumours were considered to have been sufficiently localised by angiography alone. In such vascular tumours, angiography provides a greater accuracy of localisation than is possible with pneumography and also affords evidence of the pathological nature of the mass. Many of the avascular tumours were also considered to have been satisfactorily localised by angiography, but frequently it was felt that a subsequent pneumogram would provide more detailed evidence of localisation and size of the mass. Frontal and temporal lobe avascular lesions were usually considered to have been adequately localised by angiography alone. Avascular tumours in the occipital and parietal lobes, as well as deeply infiltrating tumours, usually required pneumography for additional localisation. This is in accord with the findings reported by others concerning the accuracy of localisation of tumours by angiography, according to lobes involved. In a number of instances, the additional pneumography provided no better evidence of size and location of neoplasms, but furnished useful confirmatory evidence. In some cases, pneumography afforded better evidence of localisation than was apparent on angiography, or provided additional evidence concerning the limits of extension. In a very few instances, pneumography was a failure technically, usually due to distortion of the intracranial anatomy by the mass or its secondary effects (*e.g.*, herniation of the cerebellar tonsils interfering with ventricular filling, or gross compression of the ipsilateral ventricle, preventing filling). In 98 of the 131 cases (74.8 per cent) angiography alone was employed. In only one-quarter of the cases was pneumography also performed, in an attempt to obtain additional information regarding localisation.

In view of the frequency with which a pathological diagnosis of glioma or meningioma, etc., was possible following angiog-

TABLE I: VASCULARITY AS DETERMINED IN AUTHOR'S SERIES AND THAT OF WICKBOM (3)

	Tumor Type	Vascular
Wickbom	Glioblastoma	88%
New	Astrocytoma, grades III, IV	60%
New	Astrocytoma, grade II	25%
	Astrocytoma, grade I	0
New	Ependymoma	40%
	Oligodendroglioma	50%
Wickbom	Meningioma	62%
New		64%
Wickbom	Metastases	50%
New		55%

The considerably lower percentage of the more malignant astrocytomata classed as vascular in this series, compared with Wickbom's series, may be explained partly by a difference in pathological classification and partly by the fact that no retrospection was utilised in this series. That is, a tumour was classed as avascular if the number and appearance of tumour blood vessels did not allow of a diagnosis of vascular glioma beyond reasonable doubt. In many cases, retrospection would have justified inclusion in the vascular group.

TABLE II: SAFETY OF ANGIOGRAPHY AS PERFORMED IN VARIOUS CENTRES (Modified from Sedzimir)

Author	No. of Angiograms	Time	Deaths	Permanent Complications	Transient Complications
Bull	1,000	Not stated	3	Not stated	Not stated
Dunsmore *et al.*	147	1946–50	3	4	7
Curtis	720	1945–49	1	0	6
Abbott *et al.*	174	Not stated	5	4	8
Rowbotham *et al.*	Not stated	1951–52	3	12	18
Perese *et al.*	234	1947–52	1+?6	3	19
Ver Brugghen	150	Not stated	0	0	0
Sedzimir	273	1954	0	0	0
New	757	1952–57	0	1	2

raphy (in contrast to a diagnosis of a mass of given size and site, without evidence of its pathological nature, on pneumography), the procedure had a high value in addition to its accuracy of localisation. Analysis of the type of tumour vascularity demonstrated is not within the scope of this paper. In general, the findings of Wickbom (3) were confirmed, and it proved possible to predict the pathology of the neoplasm in a gratifyingly high proportion of cases of glioma and meningioma (Table I).

In assessing the value of a diagnostic procedure, other factors than the accuracy of localisation and diagnosis must be taken into account, particularly the factors of safety to the patient and also economy of time and material.

Table II, modified from Sedzimir (4), illustrates the high degree of safety of angiography as performed in this centre (and some other centres). In a total of 757 angiograms, there were no deaths attributable to the procedure and extremely few complications of any importance. The one permanent complication was a hemiplegia in a patient showing a large malignant glioma in the rolandic area. The transient complications consisted of hemiparesis in 1 patient examined with Thorotrast and a massive haematoma in the neck in another, causing dysphagia, stridor, dyspnoea, and moderate cyanosis. The examination proved to be considerably safer than pneumography, either encephalography or ventriculography, in spite of the fact that no attempt was made to select the patients according to clinical condition. The contrast media employed have been Diodrast 40.5 per cent, with Thorotrast in the older age groups, and during the latter portion of the series Hypaque 42 per cent almost exclusively.

In general, angiography is less distressing to the patient than pneumography and takes less time.

Finally, while demonstrating that angiography, if properly utilised, provides a most satisfactory accuracy of localisation of supratentorial neoplasms, on the basis of criteria generally accepted, we have found, as Bull (5) has recently shown, that in the case of gliomata of the cerebral hemispheres, the accuracy of localisation falls short of that which should obtain in the examination of such a critical tissue as the central nervous system.

Only too frequently does any one of the above methods fail to demonstrate the full extent of infiltration of a glioma. In the most malignant and vascular of the gliomata, the peripheral margin of the tumour may be shown with a relatively high degree of accuracy, by virtue of the peripheral tumour blood vessels or tumour capillary blush. In these cases, the accuracy of localisation surpasses that of any other method of examination. Nevertheless, even in these cases, and especially in the cases where the tumours are less vascular, tumour infiltration may extend well beyond the anticipated boundaries of the lesion. If we are to obtain the maximum accuracy of localisation and diagnosis possible with present methods, supratentorial gliomata should probably be examined both by bilateral cerebral angiography and one method of pneumography, as Bull has suggested.

SUMMARY

1. Cerebral angiography can be safer and less disturbing to the patient than pneumography. It is less time-consuming than a properly conducted pneumographic study.

2. It is postulated that the majority of supratentorial space-occupying lesions are best examined first by carotid angiography. This method alone will frequently provide a pathological diagnosis in addition to a satisfactory localisation, judged by the present criteria of accuracy. A high proportion of avascular space-occupying lesions will be accurately localised (most of the exceptions will be tumours limited to the occipital or parietal lobes, to the deep central portions of the hemispheres, or very early, small lesions). A moderate number of cases will require additional pneumography, usually encephalography, to provide additional information regarding the site and extent of the lesion. Unfortunately we know that occasionally very extensive infiltrating gliomata can exist with no definite angiographic or pneumographic abnormality. A negative angiogram in the presence of reasonable clinical suspicion of a neoplasm should lead to pneumography, either within a few days if the index of suspicion is relatively high or within a few weeks if suspicion is not so great initially but symptoms and signs are progressive.

3. Suspected midline basal neoplasms are best investigated in the first instance by pneumography, unless a meningioma or other vascular mass is suspected.

4. The present aim is to use very rapid serial angiography to provide more detail of tumour circulation and to employ angiography plus pneumography in more and more cases, as the presently accepted criteria of accuracy of localisation are not felt to be satisfactory.

NOTE: I have great pleasure in expressing my gratitude to Dr. Charles Drake (Assistant Professor and Head of the Section of Neurosurgery, University of Western Ontario), for his constant encouragement, helpful criticism, and advice.

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SUMMARIO IN INTERLINGUA

Angiographia Carotidic In Le Localisation De Neoplasmas De Hamartomas Supratentorial

Angiographia cerebral pote esser plus salve e minus disturbante pro le patiente que pneumographia. Illo require minus tempore que un studio pneumographic.

Es postulate que le majoritate del lesiones a massa in le region supratentorial se examina initialmente le melio per angiographia carotidic. Frequentemente, iste methodo sol provide un diagnose pathologic in ultra de un localisation satisfactori, secundo le currente criterios de accuratia. Un alte proportion del avascular lesiones a massa pote esser localisate mesmo accuratemente. Le majoritate del exceptiones es tumores limitate al lobos occipital o parietal o al profunde portiones central del hemispherios o multo precoce lesiones de micre dimensiones. Un moderate numero de casos require pneumographia supplemental, usualmente encephalographia, pro provider information additional con respecto al sito e al mesuras del lesion. Nos sape, infelicemente, que il pote occurrer que multo extense gliomas infiltrante existe sin

definite anormalitate angiographic o pneumographic. Un angiogramma negative in le presentia de un plausibile suspicion clinic de neoplasma deberea suggerer un studio pneumographic, intra alicun dies si le indice de suspicion es relativemente alte o intra alicun septimanas si le suspicion es initialmente non troppo forte sed se accentua a causa del progresso del symptomas e signos.

Le suspecte presentia de neoplasma basal central es investigate le melio directemente per pneumographia, excepte in casos ubi il pare tractar se de meningioma o de un altere massa vascular.

Currentemente nostre objectivo es usar rapidissime angiographia serial pro provider plus detaliate informationes relative al circulation del tumor e usar angiographia sequite per pneumographia de plus in plus frequentmente, proque le currentemente acceptate criterios de accuratia del localisation non es considerate como satisfactori.

Axial Transverse Tomography of the Chest[1]

STEFAN P. WILK, M.D.

AXIAL TRANSVERSE tomography is one of the more recent advances in roentgen diagnostic procedure. Conventional tomography enables one to show in detail roentgenographic images of the structures lying in a predetermined plane of tissue, while blurring or eliminating details of the structures in other planes. Any plane which is parallel to the long axis of the body may be chosen; but sections in the frontal and sagittal planes are most commonly made. Axial transverse tomography is a method for making roentgenograms of a thin slice of the body in a plane horizontal to its long axis.

The fundamental principle in any form of tomography is that, of the three components participating in the production of a tomogram, *i.e.*, the roentgen-ray source, subject, and film, two are moving synchronously during a continuous exposure and one is stationary. The motion is of such character that the roentgenographic image of a thin slice of the body at the predetermined level remains stationary on the film, while the images outside this slice have a continuous relative displacement and consequently are blurred.

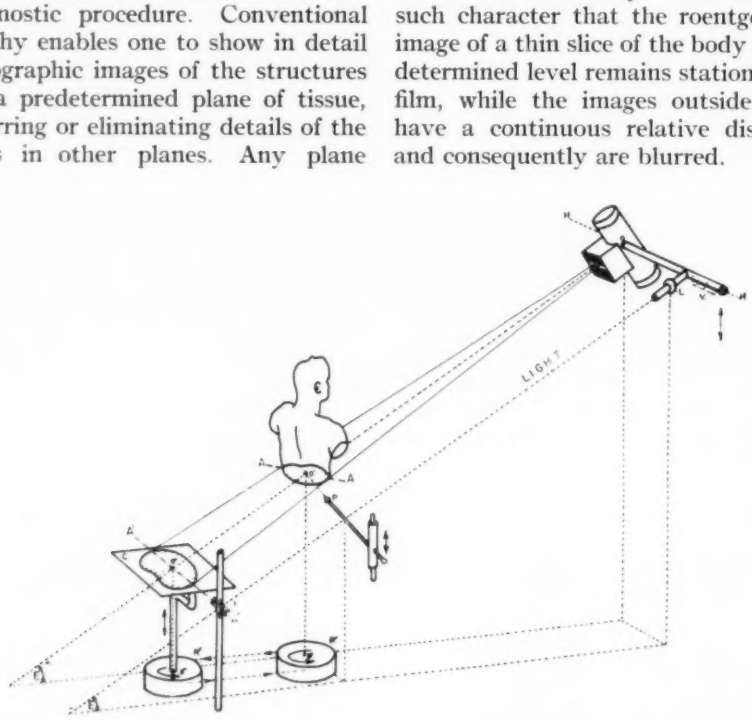


Fig. 1. Schematic drawing in perspective of the arrangement of the tube and both turntables in the Siemens apparatus (see text). (Modified from Siemens' brochure)

A theoretical solution for obtaining roentgenograms of cross sections of the body was first suggested by an American physicist, Kieffer (1), in 1938 but was not carried out practically. About the same time Watson (2) built the first practical apparatus in England. Only within the last few years, however, have the potentialities of the method been explored, mainly as a result of the great enthusiasm of Vallebona (3, 4, 5) in Italy. The method gained considerable popularity in Western

[1] The practical part of this study was done in the Department of Radiology at the University of California, Los Angeles. Presented as a scientific exhibit at the meeting of the American Roentgen Ray Society in Washington, D. C., Oct. 1–4, 1957, and on the program of the Forty-third Annual Meeting of the Radiological Society of North America, Chicago, Ill., Nov. 17–22, 1957.

Europe, where there is already a considerable volume of literature available on it. American contributions on the subject are practically nonexistent.

As far as the fundamental principle is concerned, axial transverse tomography resembles conventional planigraphy. It is obvious, however, that, because of the relatively long vertical axis of the body the technical approach of conventional tomography is of little avail. There is a variety of equipment for axial transverse tomography on the European market (6). Most of it represents modifications of the original apparatus of Watson.

Figure 1, a schematic drawing in perspective of the apparatus manufactured by Siemens, illustrates the general principle and practical aspect of axial transverse tomography. The cassette (C) is placed horizontally on a turntable (R′). The patient is immobilized in a vertical position on a turntable (R″). The x-ray beam from a rotating anode (O) emerges through a horizontal slit aperture, traverses a narrow section of the body at an angle of about 25° and strikes the film. The cassette and the tube can be moved up and down for the selection of different section levels. A spot light (L) attached to the tube carriage parallels the central ray (O-O′-O″), indicates the direction of the x-ray beam, and serves to co-ordinate the height of the tube with that of the cassette. During the exposure the tube remains stationary while the patient and the cassette rotate. Both turntables are driven by the same motor and rotate synchronously through 360° in the same direction around their vertical axes (S′-O′, S″-O″). As a result of such an arrangement of the incident x-ray beam, patient, and film, and the synchronous rotational motion of the object and the film, only a chosen thin layer horizontal to the vertical axis of the body and its roentgenographic image on the film is relatively stationary, and consequently, is sharply reproduced. All the structures below and above this level are in relative motion and thus are blurred.

Figure 2 shows the apparatus (Siemen's

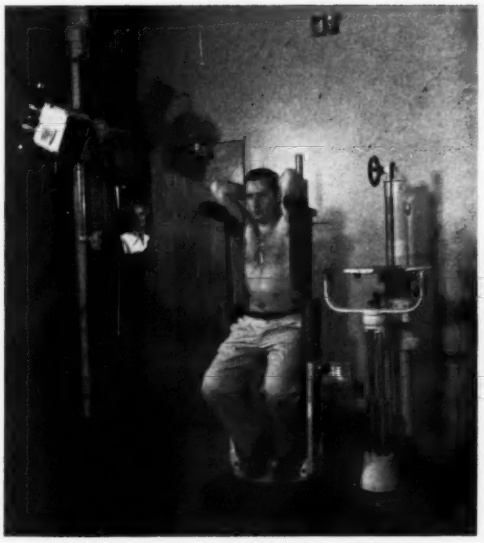


Fig. 2. Siemens "Transversal Planigraph," which was used by the writer is one of several apparatus available on the market.

"transversal planigraph") aligned for a transverse tomogram of the chest.

The roentgenogram obtained in such a way is a roentgenographic image of a cross section of the body 0.5 to 1.0 cm. thick at a chosen level. The thickness of the sharply reproduced layer depends on the angle of inclination of the roentgen beam from the horizontal plane.

DISCUSSION

Axial transverse tomography has certain inherent shortcomings due to the technical aspects.

The x-ray beam strikes the film at an angle of about 25°, *i.e.*, the image of a point is reproduced separately by the upper and lower intensifying screens and sensitive layers of the x-ray film. This results in a loss of definition. This effect diminishes with the increase of the inclination of the tube, but at the same time the thickness of the sharply reproduced layer increases. Experiments indicate that the optimum results are secured with an inclination of the beam to the horizontal of about 25°.

Due to a relatively great object-film

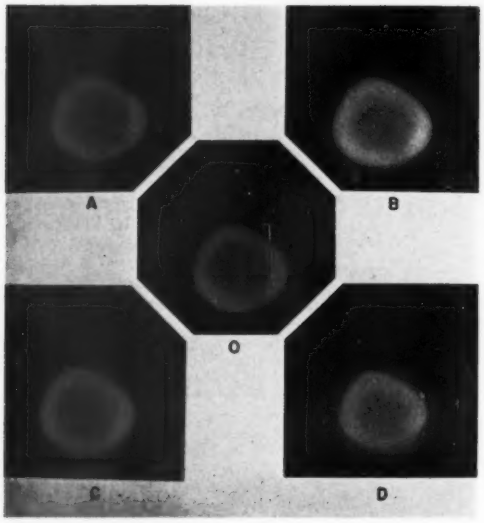


Fig. 3. Transverse tomogram of a dried femur and a wire to demonstrate the effect of the malalignment of the tube, object, and film. O. With accurate alignment, the shadow of the wire is a sharp point. With the tube out of alignment (A, by 0.05 cm.; B, by 0.1 cm.; C, by 0.2 cm.; D, by 1.0 cm.), the shadow of the wire becomes increasingly blurred the greater the malalignment. The wire is a more accurate test of alignment than the appearance of the anatomical structure. See also Figures 5, 7, 8, 9.

distance (55 cm. in Siemens apparatus), there is a high magnification factor (in our arrangement it is 35 per cent), which again results in loss of definition. Consequently, the method is of limited value where our first objective is information with regard to fine structural details.

The focal spot of the tube (O in Fig. 1) and the axes of both turntables (O′, O″) must be in almost perfect alignment. Lateral misalignment (H-H) by as little as 1 or 2 mm. results in such loss of definition that the film thus obtained may be useless for evaluation. The effect of misalignment on definition is illustrated in Figure 3. Consequently, the procedure calls for a very meticulous technician and for the close co-operation of the radiologist. Figure 3 also illustrates that the degree of sharpness of detail can be determined much better by using a metallic test wire than by judging the details of the anatomical structures.

The interpretation of such tomograms requires the additional refreshing of the memory in cross-section anatomy; as yet there are no atlases in cross-section roentgenography. For this reason one finds that a transverse tomogram of an entire cross section at a given level is of great assistance, since one side serves as a point of reference for the other. A transverse tomogram of a segment of a cross section at any level is not only difficult to interpret but lacks the most valuable aspect of the method, *i.e.*, a clear

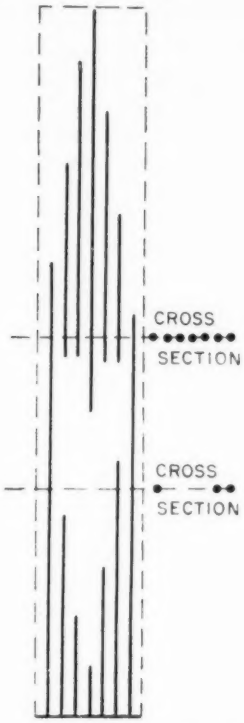
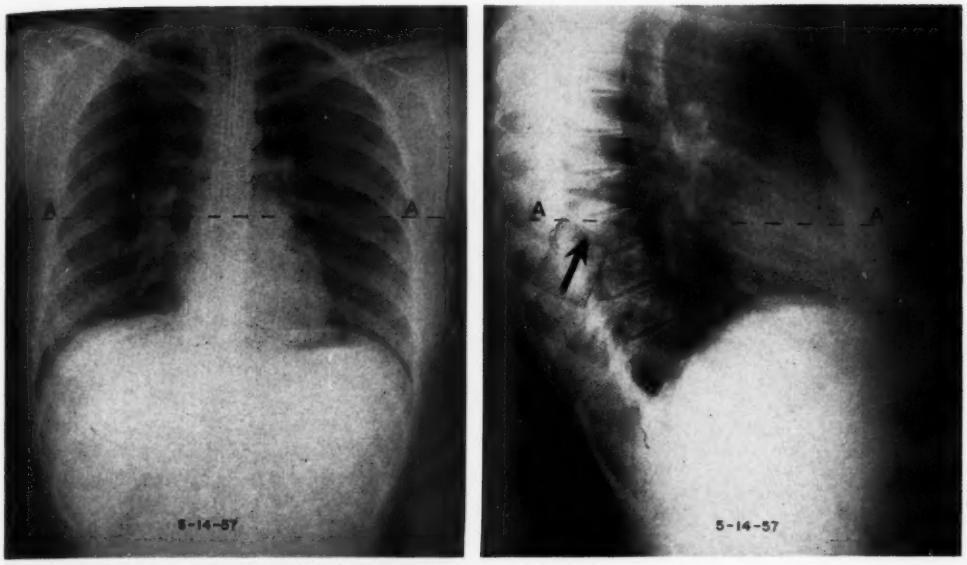


Fig. 4. Ruler for identification of section level.

insight into the all-over topographical relationship of various organs at a given level, without distortion.

The method requires a special table which is of no value for any other purpose. Several tables are available commercially, but all are manufactured in Europe. Such a table can easily be built by any mechanical shop for about $2,000.00.

The exposure to the patient per one



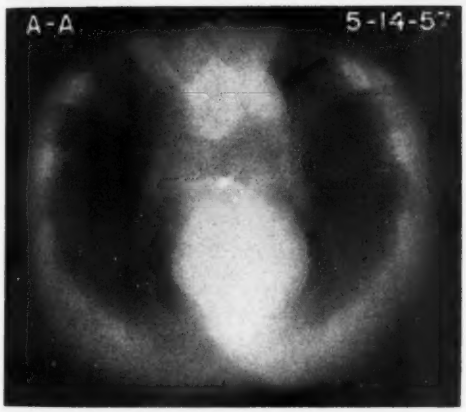


Fig. 5. Case I: Mass in the left paravertebral area in a 21-year-old girl (arrow). The transverse tomogram shows that the mass is located adjacent to the vertebral body and the transverse process. Three dots on the back identify level A-A (see the arrangement of the wires of the level identification ruler on the p-a film). The topographical relationship of the mass to the various structures of the chest is clearly visualized.

axial transverse tomogram of the chest is reported as between 0.4 and 0.6 r (7). Even though a relatively narrow strip of the body is exposed to this dose, it should be taken into consideration and the number of exposures should be limited to a minimum. Since the principal uses of axial transverse tomography are: (*a*) the obtaining of an exact cross section for the calculation of doses in the radiation therapy of deep-seated tumors and (*b*) topographical evaluation of various structures at a given cross section, a single axial transverse tomogram is all that is necessary, provided it is made at exactly the desired level, and the same level can be reproduced on subsequent study. The device to be described has proved to be valuable for the identification of the section level: a plastic ruler (Fig. 4) with vertically imbedded wires in it is attached to the back of the patient. The wires are so arranged that a different number and combination of wires appears every 1.5 cm. in the vertical direction on the transverse section (see Figs. 5 and 9). This ruler is placed on the patient's back with the topmost wire being 5 cm. below the spinous process of C-7. A postero-anterior chest film is made with the ruler properly placed. The desired section is established in relation to the wires and the transverse tomogram is made at this level. The number of wires shown on the tomogram identifies the level exactly. By this means the same level can be reproduced on subsequent tomograms without repeating the conventional chest film.

The shortcomings of the method are

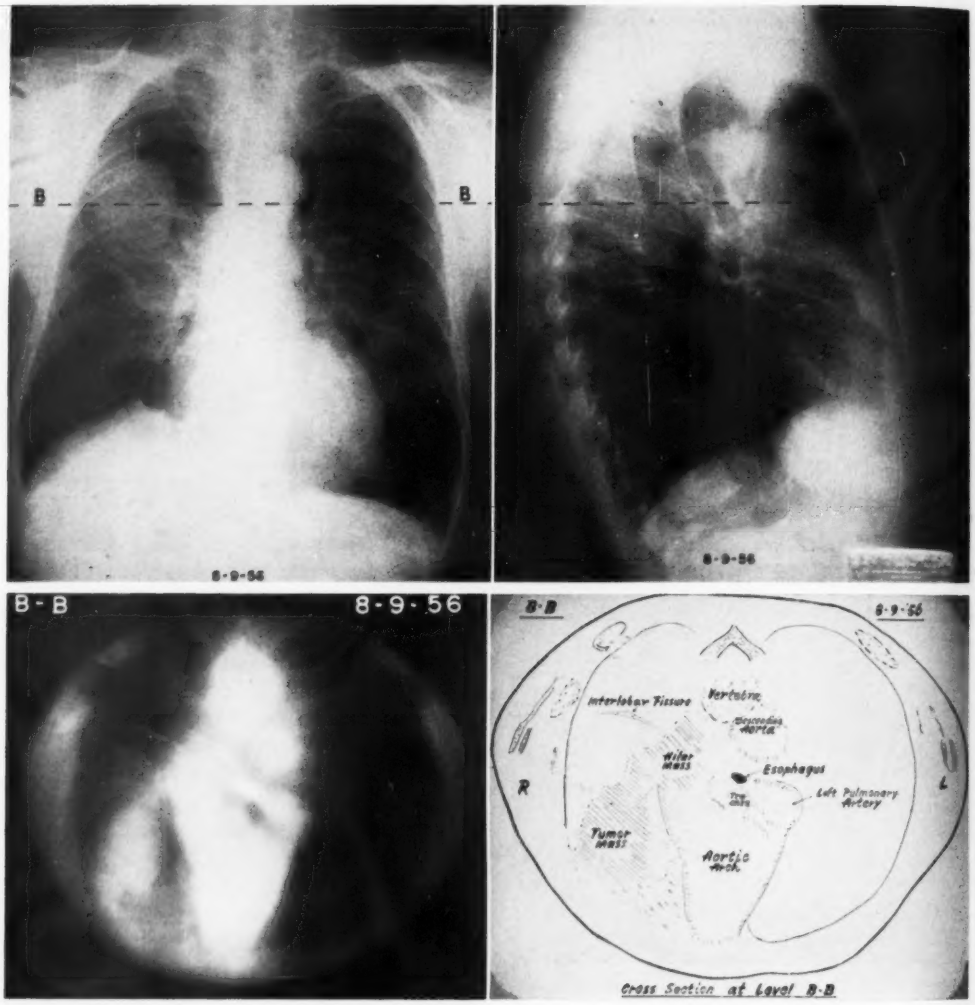


Fig. 6. Case II: Bronchogenic carcinoma on the right in a 61-year-old man. It is difficult to evaluate the exact extent of the mass and the involvement of the hilus from the conventional postero-anterior and lateral chest roentgenograms, but this is clearly shown on the transverse tomogram taken at level B-B. The accompanying tracing explains the tomogram. The comparison of the right hemithorax with the normal left side is of assistance in interpretation.

counterbalanced by its many advantages. The roentgenogram obtained by this method differs fundamentally in one respect from the conventional roentgenogram and from the tomogram in the sagittal and frontal planes. Due to the rotational motion, consisting of one full revolution of 360° during exposure, every point of the recorded image has exactly the same magnification factor, that is to say, *there is no distortion*. The magnification is established by the relative and fixed distance between the tube and each turntable. The true diameter of the various structures in the cross section can be directly measured from the transverse tomogram by means of a simple "shrink ruler." By simple photographic reduction a cross-section roentgenogram with true diameters can be obtained. By this method it is

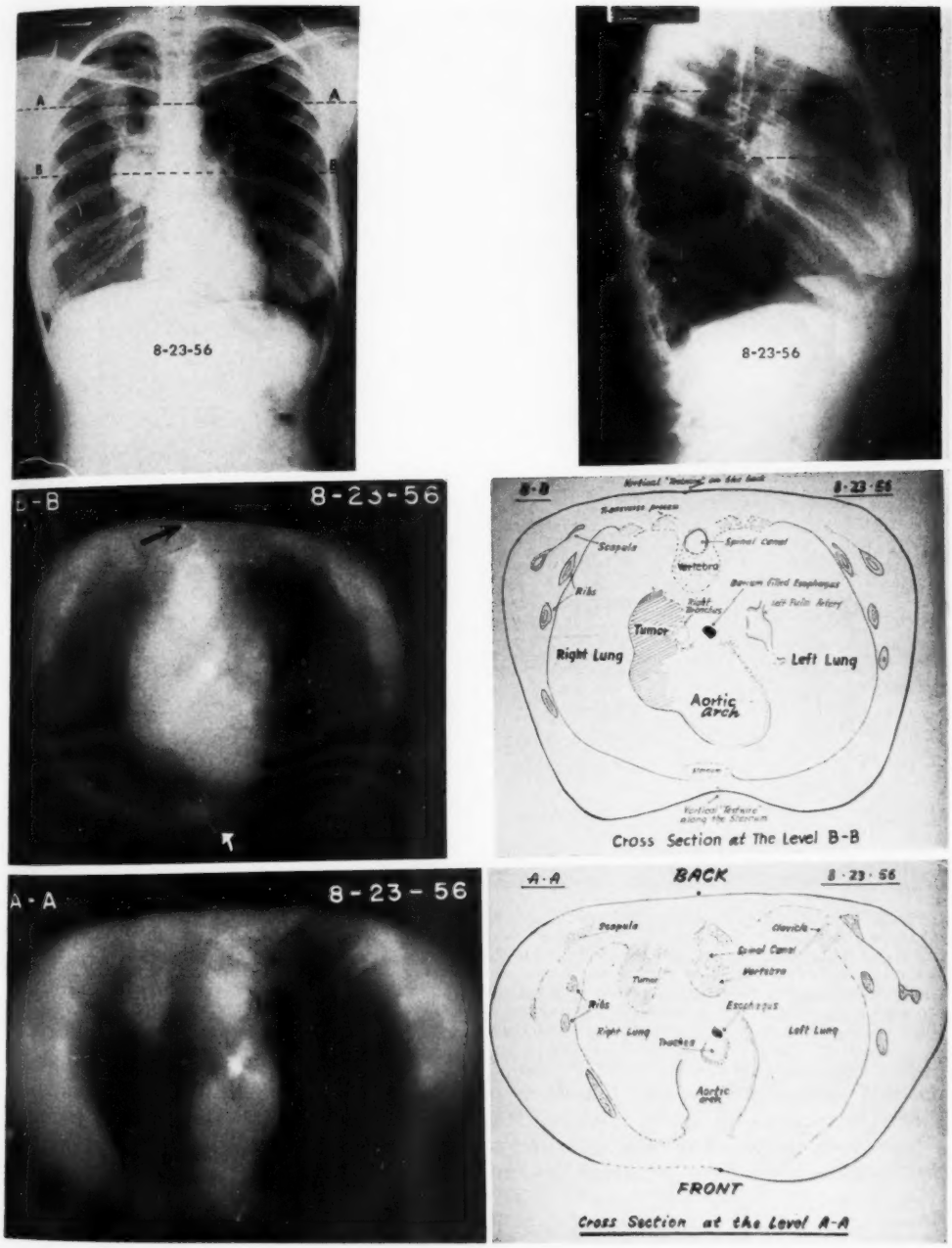


Fig. 7. Case III: Inoperable bronchogenic carcinoma in the right upper lobe and in the right hilus of a 30-year-old woman. The extent of the two masses and their relationship to the chest wall and mediastinal structures are shown in the transverse tomograms made at levels A and B. Evaluate the extent of the masses on the conventional study and compare with the information yielded by the transverse tomograms. The dots (arrows) on the back and on the front are cross sections of the wires. The sharpness of the wire on the back indicates an accurate alignment of the tube, patient, and film. The dot on the front of the chest is sharper on the section at level A than at level B, which indicates that more respiratory movement occurred on the latter than on the former during exposure. See also Case IV, Figure 8.

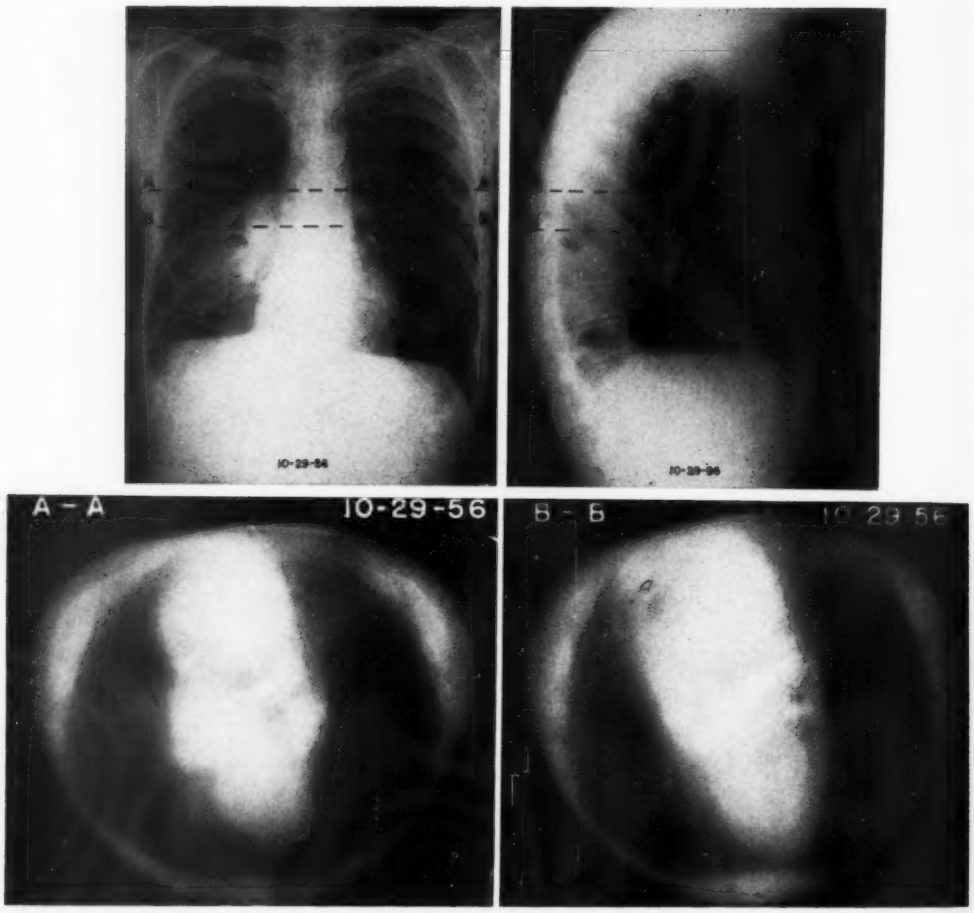


Fig. 8. Case IV: Bronchogenic carcinoma in a 71-year-old man. The conventional postero-anterior and lateral roentgenograms of the chest give little information as to the extent of the process. For interpretation of the transverse tomogram, compare the involved right hemithorax with the normal left side. The transverse tomogram at level A shows extensive involvement of the right paravertebral area, beside some involvement of the right hilar region, which is not noticeable in a conventional study. The section at level B shows the extent of the neoplastic process in the right hilar and paravertebral region, with a small area of suggestive cavitation (arrow). A tiny white dot on the back of both tomograms is explained in Figure 7.

possible to measure the true diameters of such structures as the aorta, the heart, the spinal canal, the thoracic cage, etc., and to determine exactly the depth from the skin surface of pathological processes.

The actual cross-section radiograph of the chest is of great value in planning and calculating the dosage in the radiation therapy of deep-seated tumors. This, it is believed, will prove to be one of the main advantages of the procedure.

No other radiological method enables us to gain such insight into the anatomical and topographical relationship of the various organs one to another, including the chest wall, as does the transverse tomogram. A precise and spatial record of a pathological process as to dimensions, depth, and relationship to neighboring viscera is secured.

Furthermore, the transverse tomogram yields information in obscured areas, such

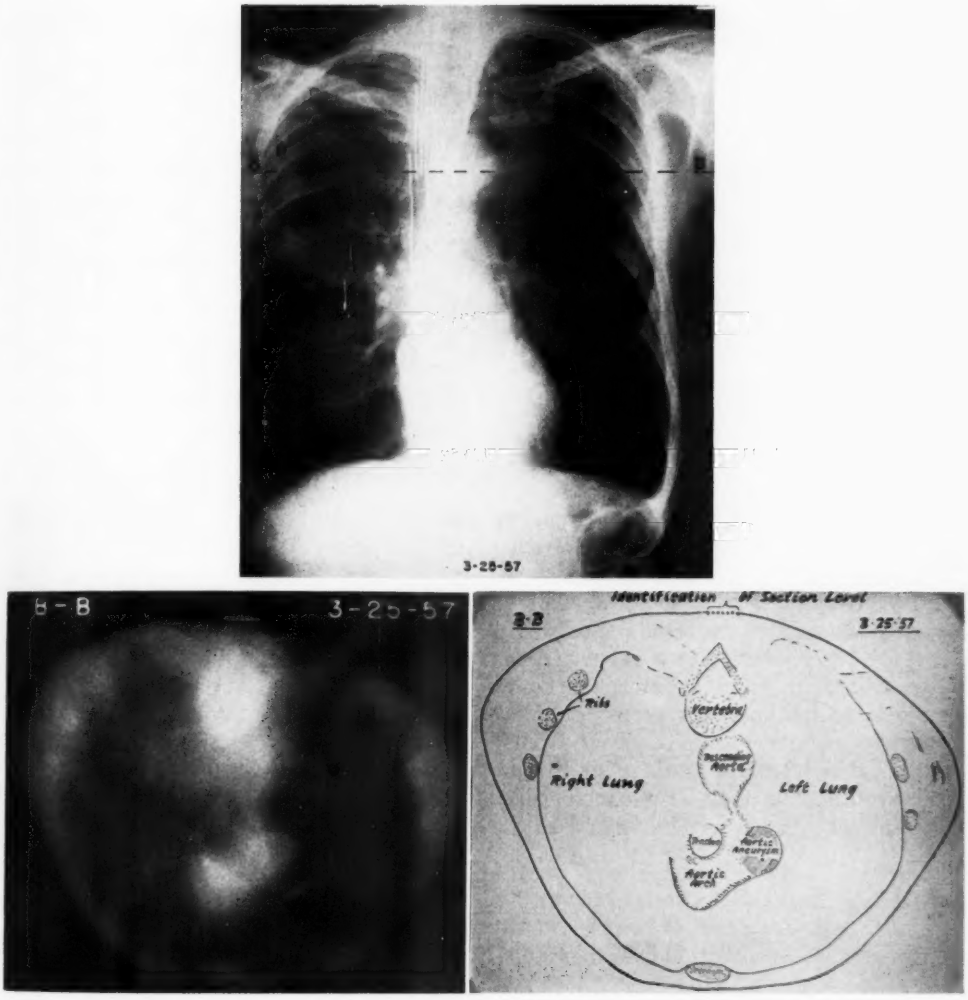


Fig. 9. Case V: Arteriosclerotic aneurysm of the thoracic aorta in a 60-year-old man. Marked difference in the density of the mass and the aortic arch on the conventional chest film was interpreted as more suggestive of a neoplasm than an aneurysm. On the transverse tomogram the relationship of the mass to the aortic arch is clearly shown, and the discrepancy in density is no longer noted. At surgery an aneurysm was found. The wires of the level-identification ruler are seen in the postero-anterior film of the chest. Seven dots on the back of the transverse tomogram indicate that the section was taken at level B-B.

as the mediastinum, which is not at present obtainable by any other method.

Several cases, with transverse tomograms of the chest, are presented to illustrate some of the aspects discussed.

SUMMARY

Axial transverse tomography is a relatively new roentgen diagnostic method for securing cross-section roentgenograms of a thin slice of the body transverse to the longitudinal axis. It requires a special table, which may be built in any mechanical workshop. This is relatively inexpensive but is of no use for any other purpose. Satisfactory results depend on highly meticulous technic. The roentgenogram obtained has relatively poor defi-

nition and, consequently, is of limited value for the visualization of fine structural details. Its main advantage is the exact reproduction of the anatomical and topographical relationship of the various organs and structures. Consequently, the procedure is of particular value to the surgeon and the radiotherapist. Because of absence of distortion, it has great potentialities for evaluating the size of various organs and determining the depth and exact extent of pathological processes.

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SUMMARIO IN INTERLINGUA

Tomographia Axio-Transverse Del Thorace

Tomographia transverse axial es un relativemente nove methodo pro obtener roentgenogrammas de un tenue section del corpore, transverse a su axe longitudinal. Le methodo require un tabula special, sed isto pote esser construite a relativemente basse costos in omne officina mechanic. Ben que le methodo ha certe inherente disavantages, per exemplo su satis basse grado de definition que rende lo inadequate pro le visualisation de fin detalios structural, ille disadvantages es contrabalanciate per multe avantages. Le principal avantage es que le methodo provide un exacte reproduction del relation anatomic e topographic del varie organos e structuras in le area studiate. Illo es de valor special in planar e calcular le dosage de radiation a tumores profunde. A causa del absentia de distorsion, le methodo ha grande possibilitates pro le evalutation del dimensiones de varie organos e pro le determination del profundor e del exacte extension de processos pathologic.

Absorbed Dose and Linear Energy Transfer in Radiation Experiments[1]

M. DANZKER, A.M., N. D. KESSARIS, M.S., and J. S. LAUGHLIN, Ph.D.

IT IS IMPORTANT in most radiation experiments to have both a quantitative measure of the amount of radiation involved, and a qualitative description of the radiation which uniquely defines its significant properties. The required quantitative measure is the absorbed dose, which is the amount of energy absorbed per unit mass of the irradiated material. This can be expressed in rads (1 rad = 100 ergs/gm.). The most pertinent qualitative description is that of the spatial distribution of the collisions by which the electrons (or other ionizing and exciting particles) which are responsible for the actual energy dissipation lose their energy. This concept has been termed "linear energy transfer" (LET) and is defined in terms of the energy lost per unit path length by the particle (1, p. 6). The LET is usually written as a function, $L(T)$, of the kinetic energy, T, of the particle and is conveniently expressed in units of kev/μ where μ is 1 micron of path length. The significant information concerning the distribution of LET in the interior of the irradiated medium is given by the total amount of track length involved per unit LET interval. The distribution of track length as a function of LET will then be $n(L)$, which is really the ionizing particle flux written as a function of $L(T)$ instead of the particle kinetic energy T.

Calculation of the primary electron source spectrum and the resultant primary slowing-down flux and LET distributions in water have already been reported by Cormack and Johns (2) for a wide range of x-ray energies used at present in therapeutic installations. In the calculations of these investigators the space-independent assumption was made that the spectrum of the x-ray beam remained constant in the interior of the irradiated medium. This restriction was removed in the high-energy region by the work of Brysk and Goldman (3), which enables calculations to be made as a function of depth of penetration. Calculations which include the total electron spectrum have been made by Burch (4), again with the assumption of space independence. We have made similar calculations of the total electron spectrum, using some results of Spencer and Attix (5), and the conclusions are compared with those of Burch.

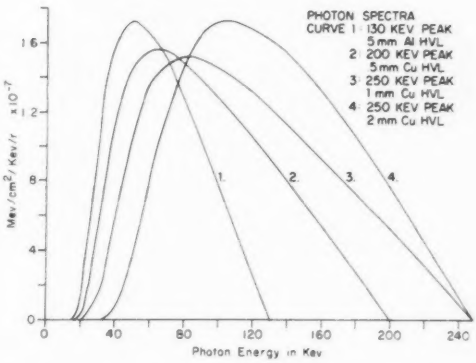

Fig. 1. Energy distributions in MEV per square centimeter per kev per roentgen of exposure dose plotted against photon energy in kev for the following (1) 130 kevp, 5 mm. Al h.v.l.; (2) 200 kevp, 0.5 mm. Cu h.v.l.; (3) 250 kevp, 1 mm. Cu h.v.l.; (4) 250 kevp, 2 mm. Cu h.v.l. Calculations made with simplified linear Kramer plot for the continuous thick target energy spectrum attenuated by the interposed filtering material.

The calculations to be presented in this paper are concerned with the methods of obtaining the absorbed dose D from cavity ionization measurements, and with the evaluation of the LET distribution function $n(L)$. The calculations have been made for seven photon spectra: (1) 130

[1] From the Division of Biophysics, Sloan-Kettering Institute, Memorial Center, New York, N. Y.
Presented at the Forty-first Annual Meeting of the Radiological Society of North America, Chicago, Ill., Dec. 11–16, 1955. Publication delayed to extend some of the LET distributions and comparisons shown in Figures 9–15.

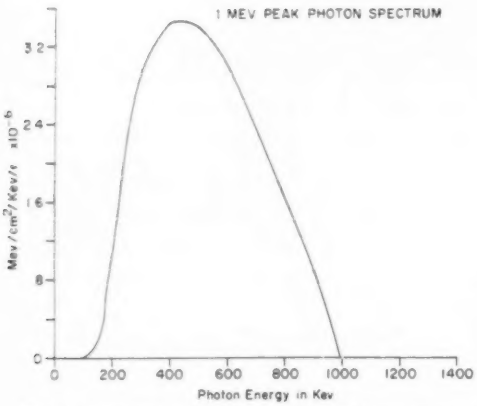

Fig. 2. Energy distribution in MEV per square centimeter per kev per roentgen of exposure dose plotted against photon energy in kev for the 1 Mv constant potential x-ray spectrum. Calculations based on simplified linear Kramer plot for the continuous thick target energy spectrum attenuated by the interposed filtering material.

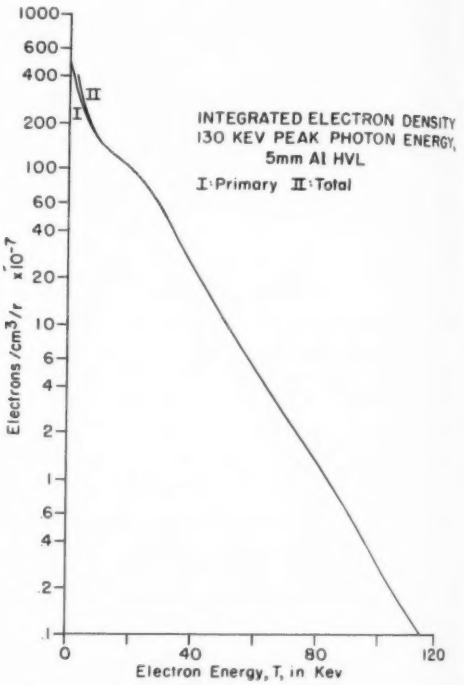

Fig. 3. Primary (plot I) and total (plot II) integrated electron source density (integrated from T to infinity) plotted against electron kinetic energy T for the 130-kvcp x-ray spectrum shown in Fig. 1. Calculated for absorption in water.

kvcp, 3 mm. Al h.v.l.; (*2*) 200 kvcp, 0.5 mm. Cu h.v.l.; (*3*) 250 kvcp, 1 mm. Cu h.v.l.; (*4*) 250 kvcp, 2 mm. Cu h.v.l.; (*5*) 1 Mevp, 3.4 mm. Pb h.v.l.; (*6*) Co^{60} gamma rays; (*7*) 25 Mevp (betatron) x-rays, uncompensated. Photon spectra 1–5 were derived with use of a simplified linear Kramer's plot for the continuous thick target emission spectrum with the attenuation of the interposed filtering material taken into consideration. The K-line radiation from the target, and Compton scattered radiation from the irradiated material, were not included. The results of Cormack and Johns (*2*) for spectra 6 and 7 were used. Spectrum 6 does not include gammas scattered by the collimator or the cobalt itself. Spectrum 7 includes the absorption by the betatron donut, monitor ionization chamber, and 4 cm. of Lucite. The neutron production of the betatron is not included.

The absorbed dose in a given irradiated material can be derived from measurements with a small cavity ionization chamber imbedded at the point in question. If the walls of the ionization chamber are made of material having nearly the same number of electrons per gram and a mean ionization potential not too different from air, if the cavity gas is air, and if the chamber is calibrated to read in roentgens, then the appropriate conversion factor to obtain absorbed dose is here written D/r in terms of rads/roentgen. If the walls of the ionization chamber are made of material identical with the medium in which it is inserted, then the appropriate conversion factor is written D/J and is given in units of rads/esu/c.c. Calculations of D/r and D/J have been made for water, polystyrene, and Lucite, for the seven spectra mentioned above. D/r was not calculated for the betatron spectrum since the roentgen cannot be conveniently measured at such high energies.

The calculation of D/r is based on the ratio of the effective mass energy absorption coefficient of the irradiated material to that of air, and requires knowledge of the photon spectrum. The conversion ratio D/J, however, and the LET distribution function $n(L)$, were calculated from

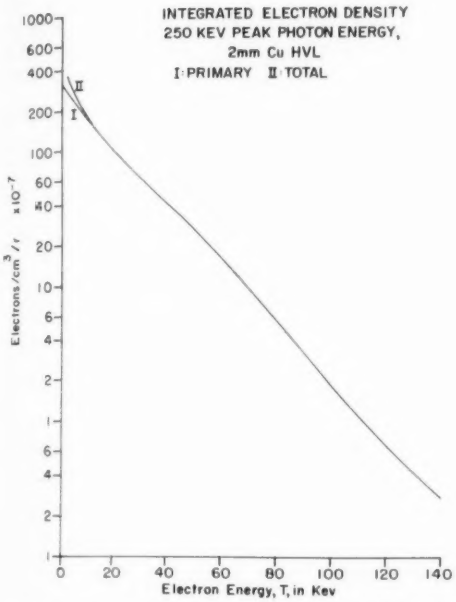

Fig. 4. The primary (plot I) and the total (plot II) integrated electron source density (integrated from T to infinity) plotted against electron kinetic energy T for the 250-kvcp, 2-mm. Cu h.v.l., x-ray spectrum shown in Fig. 1. Calculated for absorption in water.

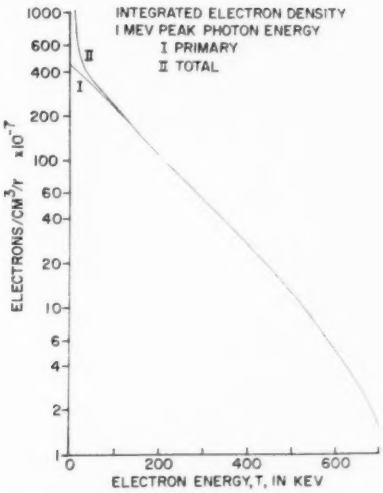

Fig. 5. Primary (plot I) and total (plot II) integrated electron source density (integrated from T to infinity) plotted against electron kinetic energy for the 1 Mv constant potential x-ray spectrum shown in Fig. 2. Calculated for absorption in water.

the total electron flux spectrum as given by the work of Spencer, Attix, and Fano (5, 6).

Since the ionizing radiations 1 through 7 consist of photons of less than 25 MEV, the only ionizing particles of significance, aside from knock-on nuclei produced by neutrons, are electrons. The LET of electrons may be taken as the electron excitation stopping power $S(T)$, which includes energy losses that result in excitation or ionization. When very energetic secondary electrons are produced, they too must be considered as part of the electron flux and not part of the energy loss in the neighborhood of the primary electron track. An energy parameter Δ is assumed such that secondary electrons projected with energies less than Δ belong to the energy loss or LET of the primary electron track, while secondary electrons projected with energies greater than Δ belong to the total electron flux. The LET can then be identified with a local excitation stopping power $S(T,\Delta)$, written concisely S_Δ, which counts only energy losses less than Δ.

CALCULATION PROCEDURE

The calculation of the LET distribution $n(L)$ then proceeds in the following steps. Start with the primary photon energy flux, $I_o(k)$, normalized per roentgen of incident radiation and derive the primary electron source distribution $N_o(T)$. Then integrate to obtain the integrated primary electron source distribution $Q_o(T)$. From the ratio of total to primary electron flux $R(T_o,T)$ at the energy T for source electrons of initial energy T_o, obtained from Spencer and Attix's formula 7 (5), the integrated total electron source distribution $Q(T)$ is determined. The primary electron flux $n_o(T)$ and the total electron flux $n(T)$ are next obtained by dividing the corresponding integrated electron source distributions by the total stopping power $S_{tot}(T)$. The LET distribution functions $n(S)$ and $n(S_\Delta)$ corresponding to the identification of LET with the collision stopping power $S(T)$ and the local excitation stopping power $S_\Delta(T)$, respectively, can be derived from the total electron flux. The ratio D/J is also calculated from the total electron flux.

The primary electron source distribution $N_o(T)$, obtained from the cross sections

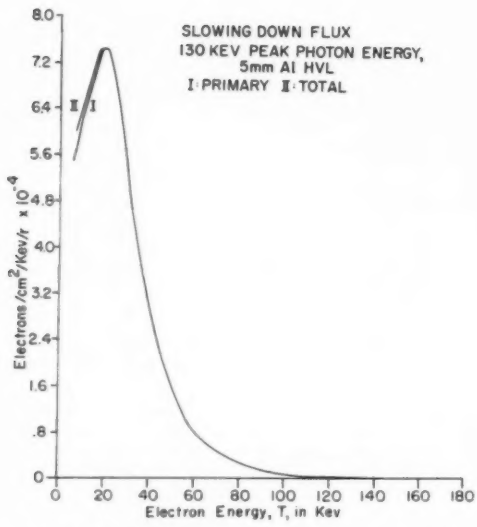

Fig. 6. Primary (plot I) and total (plot II) electron flux plotted against electron kinetic energy T for the 130-kvcp x-ray spectrum shown in Fig. 1. Calculated for absorption in water.

for the photo-electric, Compton, and pair production effects for the photon energies under consideration, was integrated from T to infinity to provide the integrated primary electron source density $Q_o(T) = \int_T^\infty N_o(T_o)\, dT_o$. This expression is the number of electrons slowing down past the energy level T. The primary electron slowing-down flux $n_o(T)$ is then obtained, under the assumption of continuous slowing down, by dividing $Q_o(T)$ by the total stopping power, $Q_o(T)/S_{tot}(T) = n_o(T)$. The function $Q_o(T)$ is given in Figures 3–5, 12d, and 13d, for the photon spectra 1 and 4–7. Spectra 2 and 3, intermediate between spectra 1 and 4, do not show any new features; therefore, these and subsequently derived graphs for spectra 2 and 3 will not be shown. The function $n_o(T)$ is given in Figures 6–8, 12c, and 13c for the photon spectra 1 and 4–7.

The total stopping power used in the above calculation is given by the sum of the Bethe-Bloch formula (7) for electron-electron and electron-molecular collisions, the radiative loss formula (8) for electron-nuclear collisions, and the density effect for high-energy electrons as computed for water by Sternheimer (9). The local stopping power $S(T,\Delta)$ is obtained from Spencer and Attix's formula 8 (5). For betatron energies the total density effect is included, which amounts to the assumption that there is no density effect for energy losses larger than Δ.

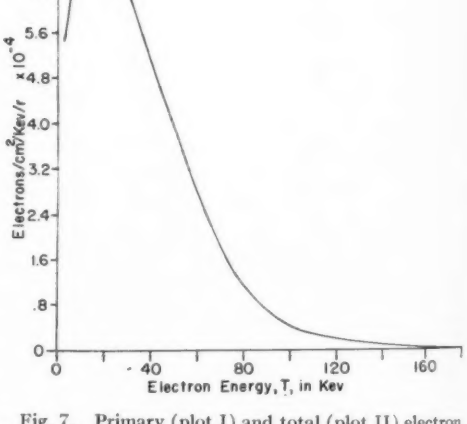

Fig. 7. Primary (plot I) and total (plot II) electron flux plotted against electron kinetic energy T for the 250-kvcp, 2-mm. Cu h.v.l., x-ray spectrum shown in Fig. 1. Calculated for absorption in water.

The constants used in the stopping power calculations are mean ionization potentials, I, of 63.0 ev, 63.2 ev, 60.9 ev, and 80.5 ev, and electron densities of 0.334×10^{24}, 0.325×10^{24}, 0.324×10^{24}, and 0.301×10^{24} electrons per gram for water, Lucite, polystyrene, and air, respectively. The energy required to produce one ion-pair in air is taken to be $W_a = 34.1$ *ev/ion-pair* $= 0.1137$ *erg/e.s.u.*

In the process of slowing down, the primary electrons produce secondaries of lower energy. In an electron-electron collision the secondary electron is defined as the particle which receives up to half of the initial energy of the primary. The total electron slowing-down flux, including all secondary electrons, is given by an integral equation which has been solved by Spencer.

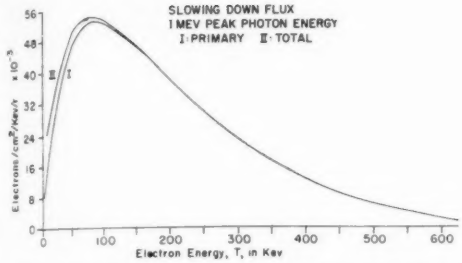

Fig. 8. Primary (plot I) and total (plot II) electron flux plotted against electron kinetic energy T for the 1 Mv constant potential x-ray spectrum shown in Fig. 2. Calculated for absorption in water.

When the solution of this integral equation is written in the form of the ratio of total to primary electron slowing-down flux at energy T arising from primaries of energy T_o, $R(T_o, T)$, then the integrated total source distribution is given by $Q(T) = \int_T^\infty R(T_o, T)\ N_o(T_o)\ dT_o$, and the total slowing-down flux is then given by $n(T) = Q(T)/S_{wt}(T)$.

The function $Q(T)$ is given in Figures 3-5, 12d, and 13d for the photon spectra 1 and 4–7. The total function $n(T)$ for these spectra is given in Figures 6–8, 12c, and 13c. In the region of low energies $Q(T)$ is proportional to $1/T$, as calculated here, for spectrum 1 in the region $T <$ 300 ev, and for spectrum 7 in the region T < 200 kev.

The difference in LET distribution depending on the choice of excitation stopping power $S(T)$ and local excitation stopping power $S(T,\Delta)$ for LET is illustrated in Figures 9–11, 12b, 13b, which present the two sets of curves for spectra 1 and 4–7, with a cut-off energy Δ of 5.1 kev. This cut-off energy is useful in the calculation (5) of D/J for cavity ionization chambers of a size equal to the range of 5.1-kev electrons in the cavity gas: 0.6 mm. for air at *STP*.

ABSORBED DOSE

The energy absorbed per unit mass from a flux of photons is given by $D_i = \int_0^\infty I(k)\ \mu_a\ (k)\ dk/\rho$ at the point at which the energy is removed. The subscript i refers to initial absorption. The density of the medium is ρ, the energy absorption cross section in cm.$^{-1}$ is $\mu_a(k)$, and the energy flux of photons of energy k at the point in question is $I(k)$. The initial absorption is not in general the same as local absorbed dose, unless we are dealing with a space-independent problem. The local absorbed dose is closely given by the approximate formula $D_o = \int_0^\infty n_o(T) S^W(T)\ dT/\rho$, where $S^W(T)$ is the excitation stopping power of the material at the point in question, and $n_o(T)$ is the primary slowing-down flux of electrons. The expression for D_o is not precise for the local absorbed dose because of the long ranges of some of the electrons which are included in the excitation stopping power $S^W(T)$, which contains energy losses up to half the electron energy T of the primary. In order to define only local absorption, it is necessary to use a local

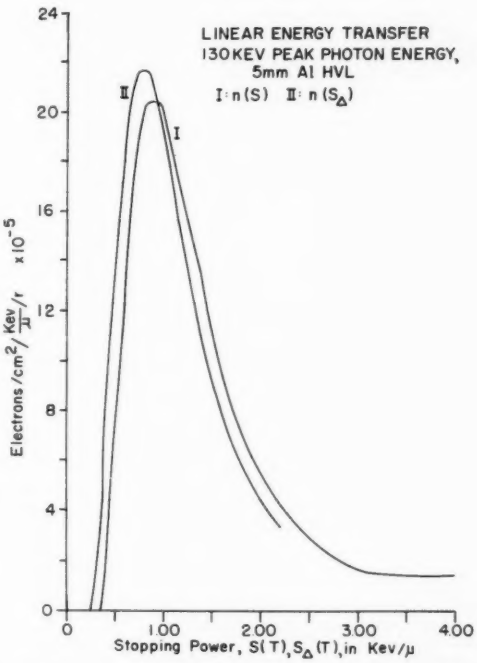

Fig. 9. The LET distributions n(S) and n(SΔ) plotted as a function of the excitation stopping power S(T) and the local excitation stopping power SΔ(T), respectively, with a cut-off energy Δ of 5.1 kev. Calculated for the 130-kvcp x-ray spectrum shown in Fig. 1 for absorption in water.

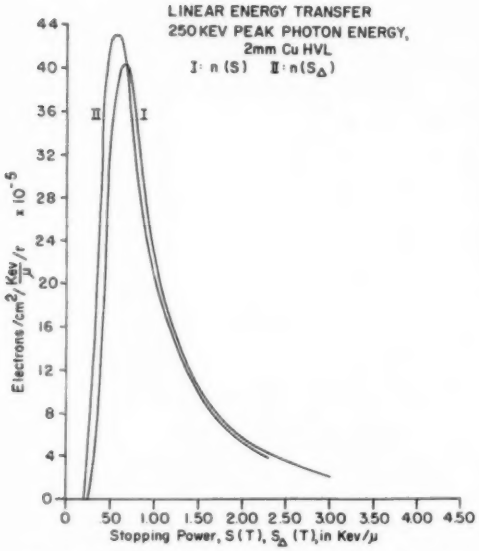
LINEAR ENERGY TRANSFER
250 KEV PEAK PHOTON ENERGY,
2mm Cu HVL
I: n (S) II: n(S$_\Delta$)
Electrons /cm^2/ $\frac{Kev}{\mu}$ /r x 10^{-5}
Stopping Power, S(T), S$_\Delta$ (T), in Kev/μ

Fig. 10. The LET distributions n(S) and n(SΔ) plotted as a function of the excitation stopping power S(T) and the local excitation stopping power SΔ(T), respectively, with a cut-off energy Δ of 5.1 kev. Calculated for the 250 kvcp, 2-mm. Cu h.v.l., x-ray spectrum shown in Fig. 1 for absorption in water.

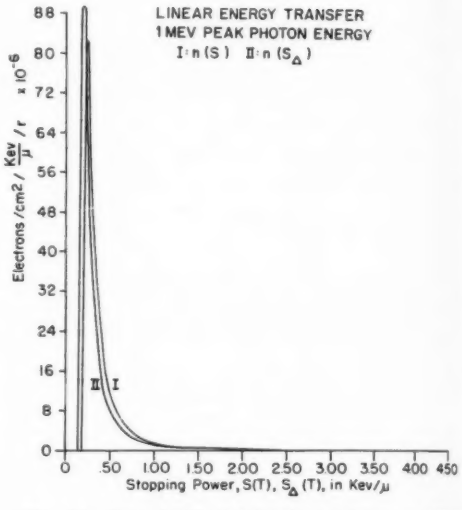
LINEAR ENERGY TRANSFER
1 MEV PEAK PHOTON ENERGY
I: n (S) II: n (S$_\Delta$)
Electrons /cm2 / $\frac{Kev}{\mu}$ /r x 10^{-6}
Stopping Power, S(T), S$_\Delta$ (T), in Kev/μ

Fig. 11. The LET distributions n(S) and n(SΔ) plotted as a function of the excitation stopping power S(T) and the local excitation stopping power SΔ(T), respectively, with a cut-off energy Δ of 5.1 kev. Calculated for the 1 Mv constant potential x-ray spectrum shown in Fig. 2 for absorption in water.

excitation stopping power (5) $S^W(T, \Delta)$ which counts only energy losses less than Δ. The local absorbed dose is then given by $D = \int_\Delta^\infty n(T)S^W(T, \Delta)\,dT/\rho$, where $n(T)$ is the total electron flux and Δ is the cut-off energy which determines the size of the local region in which the absorbed dose D is computed. For both D_o and D special care must be taken with the lower limit of integration. The local stopping power $S(T, \Delta)$ from $T = \Delta$ to 2Δ takes care of the residual energy of primaries which drop below Δ in energy.

When a small cavity filled with gas is placed within a medium in which a photon flux exists, there will be a production of ion pairs in the gas. The charge produced by the radiation may then be collected and is considered as a result of the flux of electrons originating in the material of the wall surrounding the cavity. An approximate formula for the ionization produced per unit volume J in the cavity is given by $J_o = \int_0^\infty n_o(T)S^a(T)dT/W_a$, where $S^a(T)$ is the excitation stopping power for the cavity gas and W_a the average energy required to produce a unit of charge in the gas. Since J_o is independent of the dimensions of the cavity, it can have meaning only when the cavity ionization is experimentally insensitive to cavity dimensions. As a first order attempt to take cavity size into consideration, write $J = \int_\Delta^\infty n(T)S^a(T, \Delta)dT/W_a$, where the functions in the integrand are described in the previous paragraph on local absorbed dose. The energy limit Δ, instead of being somewhat arbitrary, is now related to the size of the cavity. It is necessary to remember that the lower limit in the integrals for J_o and J requires special consideration, as also for the absorbed dose formulae for D_o and D. The formulae for D_o/J_o and D/J then represent the conversion ratios of absorbed dose to cavity ionization as calculated from the primary and total electron flux, respectively. The difference from the result obtained with the Bragg-Gray formula lies in the manner of obtaining the average stopping power ratio for the cavity wall to the cavity gas.

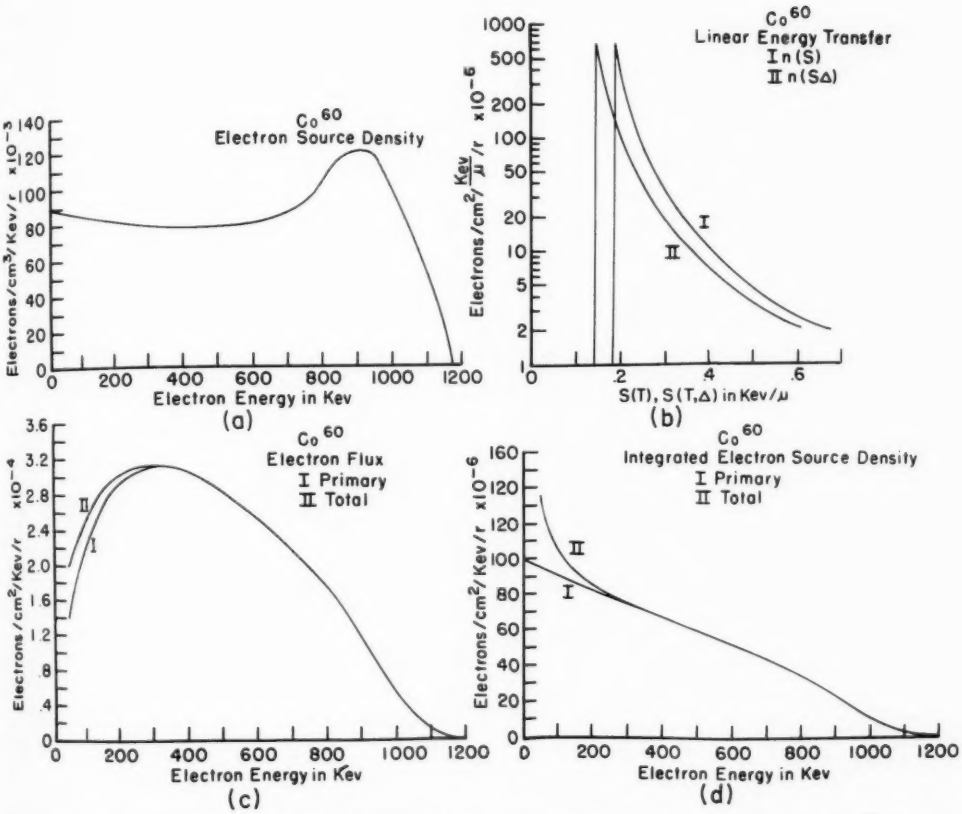

Fig. 12. Electron distributions plotted against electron kinetic energy T, for Co^{60} gammas. a. Primary electron source density, smoothed out distribution obtained from reference 2. b. LET distributions n(S) and n(SΔ) plotted as a function of the excitation stopping power S(T) and the local excitation stopping power SΔ(T), respectively, with a cut-off energy Δ of 5.1 kev. c. Primary (plot I) and total (plot II) electron flux. d. Primary (plot I) and total (plot II) integrated electron source density (integrated from T to infinity). Calculations for absorption in water.

The results for D/J for water, Lucite, and polystyrene are given in Table I, together with the results for D/r. The inclusion of Compton source electrons with ranges in air less than the average dimension of the cavity results in a decrease of D/J with softer spectra for wall materials having an average atomic number less than air. The use of primary electron distributions, which do not allow consideration of a finite cavity size, do not exhibit such a decrease of D/J with softer spectra. The results, however, differ from those calculated with total electron distributions by 2 per cent or less, for wall materials and photon spectra used here. The values obtained for D_o/J_o are: 1.04 rads/esu/c.c., 1.04 rads/esu/c.c., 1.03 rads/esu/c.c., 1.03 rads/esu/c.c., 1.02 rads/e.s.u./c.c. for spectra 1 to 5, respectively, as calculated with only the primary electron spectrum.

The absorbed dose in a medium may be obtained from cavity ionization measurements at the point in question through the use either of the conversion ratio D/J or the ratio D/r for photon energies for which the roentgen is experimentally defined. The calculation in either case requires the use of the photon spectrum. However, where the conversion ratio changes slowly with the quality of the photon spectrum, the precise resolution of the spectrum is unimportant. The use of the ratio D/J enables one to avoid the requirements of

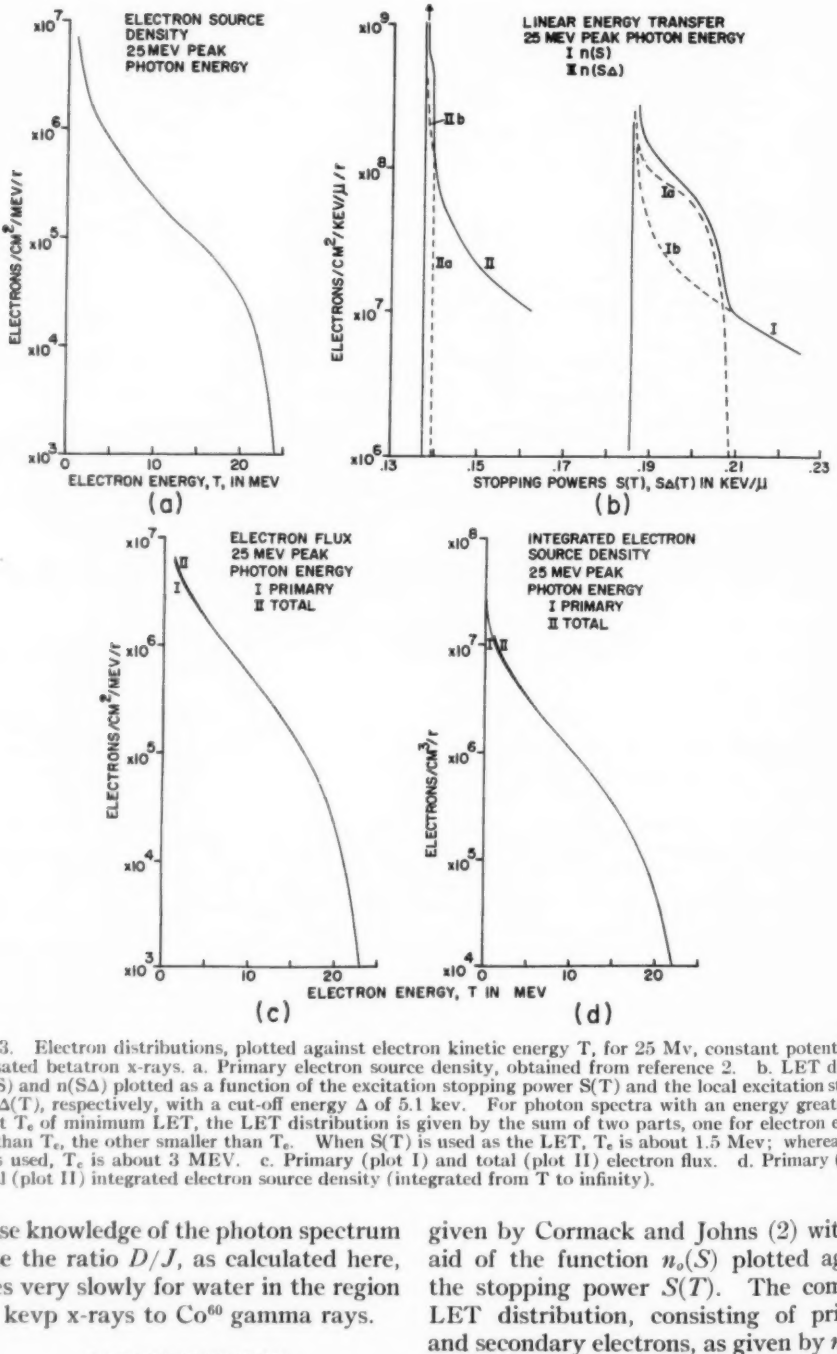

Fig. 13. Electron distributions, plotted against electron kinetic energy T, for 25 Mv, constant potential, uncompensated betatron x-rays. a. Primary electron source density, obtained from reference 2. b. LET distributions n(S) and n(SΔ) plotted as a function of the excitation stopping power S(T) and the local excitation stopping power SΔ(T), respectively, with a cut-off energy Δ of 5.1 kev. For photon spectra with an energy greater than the point T_e of minimum LET, the LET distribution is given by the sum of two parts, one for electron energies greater than T_e, the other smaller than T_e. When S(T) is used as the LET, T_e is about 1.5 Mev; whereas when SΔ(T) is used, T_e is about 3 MEV. c. Primary (plot I) and total (plot II) electron flux. d. Primary (plot I) and total (plot II) integrated electron source density (integrated from T to infinity).

a precise knowledge of the photon spectrum because the ratio D/J, as calculated here, changes very slowly for water in the region of 130 kevp x-rays to Co^{60} gamma rays.

LET DISTRIBUTION

Distributions of LET for primary electrons slowing down in water have been given by Cormack and Johns (2) with the aid of the function $n_o(S)$ plotted against the stopping power $S(T)$. The complete LET distribution, consisting of primary and secondary electrons, as given by $n(L)L$ plotted against L, has been published by Burch (4). Burch has identified the LET function $L(T)$ with the local stopping

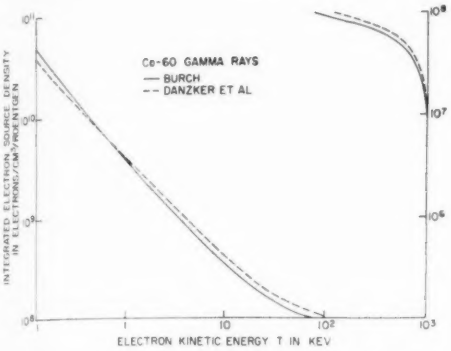
Co-60 GAMMA RAYS
— BURCH
-- DANZKER ET AL
INTEGRATED ELECTRON SOURCE DENSITY IN ELECTRONS/CM³/ROENTGEN
ELECTRON KINETIC ENERGY T IN KEV

Fig. 14. Integrated electron source density calculated for Co^{60} primary photons in water. The solid plot is obtained from Table IV of Burch (4). The dashed plot is our calculation using Formula 7 given by Spencer and Attix (5).

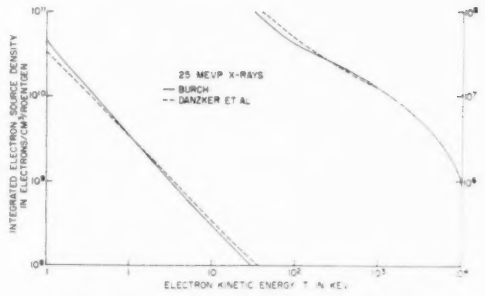
25 MEVP X-RAYS
— BURCH
-- DANZKER ET AL
INTEGRATED ELECTRON SOURCE DENSITY IN ELECTRONS/CM³/ROENTGEN
ELECTRON KINETIC ENERGY T IN KEV

Fig. 15. Integrated electron source density calculated for 25-MEV betatron primary photons in water. The solid plot is obtained from Table 4 of Burch (4). The dashed plot is our calculation using formula 7 given by Spencer and Attix (5).

power $S_\eta(T)$, which differs from the local stopping power $S(T, \Delta)$ used by Spencer and Attix (5) principally in the range $T = \Delta$ to $T = 2\Delta$. The basic meaning of the quantities Δ and η remain the same: only energy losses less than Δ or η are to be included in the local stopping power. However, an electron in the energy range between Δ and 2Δ can lose up to half of its energy in a collision with a free electron. In the formula of Spencer and Attix, the energy of the primary as well as the secondary is included in the stopping power if the primary loses enough energy to drop below Δ.

The curves of Figure 16 represent the complete LET distribution function $n(L)$ plotted against L where $L(T)$ has been set equal to $S_\eta(T)$ with $\eta = 100$ ev, Burch's formula 17 (10). The total electron spectrum is calculated according to the method given by Spencer and Attix (5). The function $n(L)$ was plotted down to values of LET of 27 kev/micron, which corresponds to an electron energy of 100 ev. Values of stopping power for T less than 100 ev are not very well known, and the best procedure is to lump all the energy involved in a single term which is an integral of $n(L)L$, from T equals zero to T equals 100 ev, as given by Burch (4). The stopping power in water below 5 kev begins to deviate from the Bethe-Bloch formula, and Figure 16 will then be qualitative in nature above

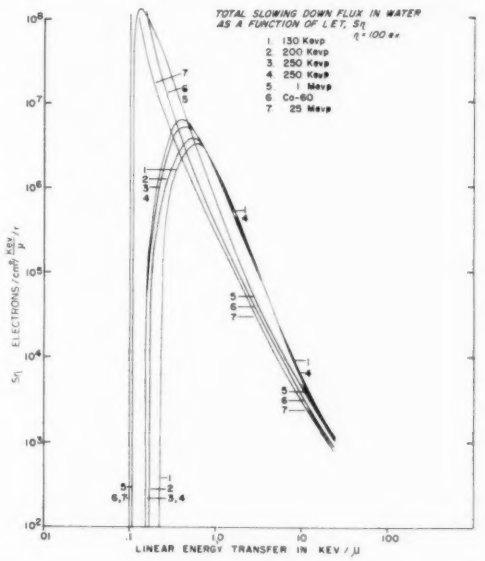
TOTAL SLOWING DOWN FLUX IN WATER AS A FUNCTION OF LET, Sη
η = 100 ev
1. 130 Kevp
2. 200 Kevp
3. 250 Kevp
4. 250 Kevp
5. 1 Mevp
6. Co-60
7. 25 Mevp
Sη ELECTRONS/cm² KEV/μ/r
LINEAR ENERGY TRANSFER IN KEV/μ

Fig. 16. LET distributions $n(S_\eta)$ in water for primary and secondary electrons resulting from various photon spectra plotted in units of electrons per square centimeter per kev per micron per roentgen of exposure dose. The local excitation stopping power $S_\eta(T)$ and the excitation stopping power S(T) are not well known below about 5 kev in water, corresponding to a LET of about 4 kev/micron. The critical energy η is taken to be 100 ev.

a corresponding LET of about 4 kev/micron.

The values of $Q(T)$ for low T were obtained by extrapolating down to a minimum value of $T = T_{min}$, which gives the total number of ion pairs (each electron represents exactly one ion pair) in water, calculated by assuming 33 ev per ion pair.

TABLE I: RATIOS OF ABSORBED DOSE TO FREE AIR AND CAVITY IONIZATION*
(D/r in rads/roentgen, D/J in rads/e.s.u./c.c.)

Photon Spectrum	Water		Lucite		Polystyrene	
	D/r	D/J	D/r	D/J	D/r	D/J
130 kevp 5 mm. Al h.v.l.	0.91	1.03	0.66	1.00	0.52	0.99
200 kevp 0.5 mm. Cu h.v.l.	0.93	1.03	0.76	1.00	0.67	1.00
250 kevp 1 mm. Cu h.v.l.	0.95	1.03	0.84	1.00	0.79	1.00
250 kevp 2 mm. Cu h.v.l.	0.97	1.03	0.91	1.00	0.88	1.00
1 Mevp 3.4 mm. Pb h.v.l.	0.98	1.02	0.95	0.99	0.95	0.99
Co^{60}	0.98	1.02	0.95	0.99	0.95	0.99
25 Mevp		0.96		0.93		0.93

* This table has been published in part in Radiation Dosimetry (New York, Academic Press, 1956, p. 904). The values of D/r for water recently published in Table 2 of National Bureau of Standards *Handbook 62* (1) agree with those in the above table to within 1 per cent.

This is a fictitious value but is intended to give only an order of magnitude for $Q(T)$. Values of T_{min} were found of from 5 to 10 electron volts, which are supposed to represent the minimum ionization potential, and which correspond to $Q(T_{min}) = 1.6 \times 10^{12}$ electrons/cm.^{3}/r in water. All LET distribution curves should have the same behavior at high LET's if the value of W for water is not energy-dependent for irradiation involved.

The calculations of total electron spectra performed by us can be compared with those of Burch (4), in which secondary electrons are also included. The comparison is given in Figures 14 and 15 where integrated electron source density, $Q(T)$ in our notation and $N_T(T)$ in the notation of Burch are plotted against electron kinetic energy T. The results of Burch for water, obtained from his Table 4 have been normalized to read electrons/c.c./roentgen instead of electrons/gm./rad. There is good overall agreement between the results of Burch and those obtained here based on a formula of Spencer and Attix (5).

DISCUSSION

This paper has emphasized the significance of both absorbed dose and linear energy transfer (LET) distribution in the use of radiation. The importance of employing the total electron spectrum in calculations of these quantities has been illustrated. Most irradiations are actually performed with continuous x-ray spectra from machines, or combinations of monochromatic gamma-rays from radioactive isotope sources. Details of the calculation of the absorbed dose are illustrated for various continuous x-ray spectra with peak energies from 130 kev to 22.5 MEV, and for cobalt gamma-rays. Conversion factors to obtain the absorbed dose in rads in various materials from measurements in terms of the roentgen are presented. It is hoped that this presentation will facilitate the practical use of the rad. Calculations of LET distribution for these same spectra are also illustrated and their significance discussed.

The application of a limit Δ to the energy loss associated with any collision event has two immediate consequences:

1. The LET distribution is shifted to decreased values and the minimum LET possible is decreased. This follows directly the decreased amount of energy loss allowed per unit path length.

2. The radius of action around the path of the electron is seen to be decreased since the higher-energy secondary electrons dissipate their energy furthest from the track.

This treatment of electron energy loss with the application of the energy limit provides a picture of the instantaneous spatial distribution of collisions which corresponds more closely to physical reality. Whether or not the difference in LET distribution for the x-ray energies discussed here will correspond to different biological reactions will depend critically on the dimensional features of the particular reaction (target size, migration of radicals, etc.).

SUMMARY

1. The significance of the total and primary degraded electron spectra are discussed and the application of the theory developed by Fano and Spencer to the calculation of total electron spectra is illustrated for irradiation of water by the following x-ray qualities: 130 kvcp, 5 mm. Al h.v.l.; 200 kvcp, 0.5 mm. Cu h.v.l.; 250 kvcp., 1 mm. Cu h.v.l.; 250 kvcp, 2 mm. Cu h.v.l.; 1 Mevp, 3.4 mm. Pb h.v.l.; Co^{60} gamma rays; 25 Mevp betatron x-rays.

2. The significance of absorbed dose is discussed. The absorbed dose relative to the roentgen (D/r) and to cavity ionization (D/J) with absorbing materials of water, Lucite, and polystyrene is calculated and tabulated.

3. The linear energy transfer (LET) distributions produced by the continuous electron spectra are shown graphically.

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SUMMARIO IN INTERLINGUA

Doses Absorbite E Transferimento Linear De Energia In Experimentos De Radiation

Es sublineate le signification del dose absorbite si ben como del distribution del transferimento linear de energia in le uso de radiation. Le importantia de utilisar le total spectro electronic in le calculation de ille quantitates es illustrate.

Le theoria disveloppate per Spencer e Fano (pro le calculation de total spectros electronic vide Physical Rev. 93: 1172, 15 de martio 1954) es applicate al sequente qualitates de radios X: 130 kvcp, spissitate de medie valor 5 mm de Al; 200 kvcp, spissitate de medie valor 0,5 mm de Cu; 250 kvcp, spissitate de medie valor 1,0 mm de Cu; 250 kvcp, spissitate de medie valor 2,0 mm de Cu; Mevp, spissitate de medie valor 3,4 mm de Pb; radios gamma per Co^{60}; 25 Mevp de radios X de betatron.

Le dose absorbite relative al ionisation de roentgen e de cavitate con materiales absorbente de aqua, Lucite, e polystyreno es calculate e tabulate.

Le distributiones de transferimento linear de energia, que es producite per le spectros electronic continue, es presentate graphicamente.

Broad Beam Attenuation in Concrete for 50 to 300-Kvp X-Rays and in Lead for 300-Kvp X-Rays[1]

E. DALE TROUT, B.S., D.Sc., JOHN P. KELLEY, B.S., and ARTHUR C. LUCAS, B.S.

BROAD BEAM ATTENUATION DATA IN CONCRETE, 50 TO 300 KVP

For x-ray installations up to 400 kvp it has been the general practice to use lead as the shielding material; at the lower voltages lead is a very effective barrier, since attenuation is largely due to photoelectric absorption. With the increased use of concrete for structural purposes in walls, floors, and ceilings of new buildings, it may be desirable to use concrete rather than lead as the barrier material. In existing structures, concrete may provide all or part of the necessary protection.

Attenuation data for lead have been generally available. For concrete, attenuation data have been available for the higher voltages but not generally for low voltages. The reason for this lack of information in the lower voltage range lies in the fact that the data must be obtained with large fields (at least 3 feet in diameter) at the barrier. Large sheets of concrete of thin section are not easily made and do not lend themselves to the repeated handling required in experimental studies.

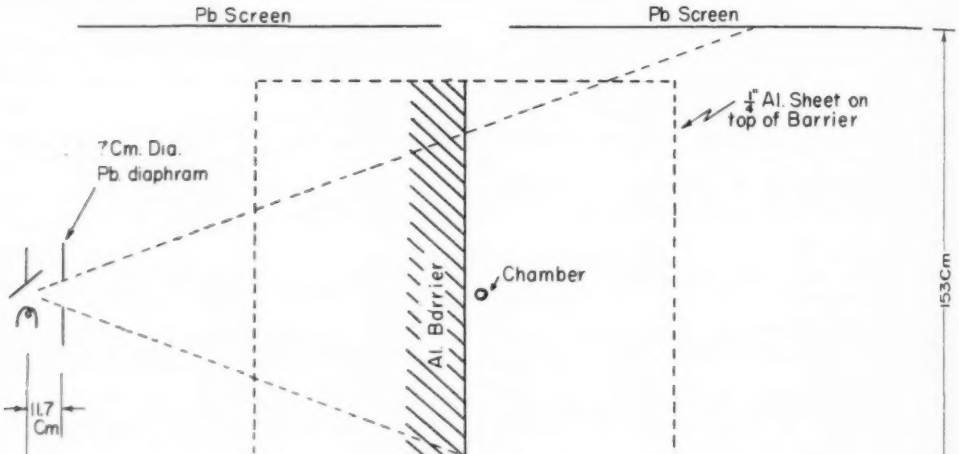

Fig. 1. Plan view of geometry for aluminum attenuation data.

Wyckoff, Kennedy, and Bradford (1) and Miller and Kennedy (2) described the need for broad-beam attenuation data in barrier design. Miller and Kennedy also called attention to the fact that, since attenuation at the lower voltages in materials of low atomic number is largely due to Compton scattering, it should be possible to take attenuation data in other material of low atomic number and, by applying the necessary corrections, derive data for

[1] Accepted for publication in April 1958.

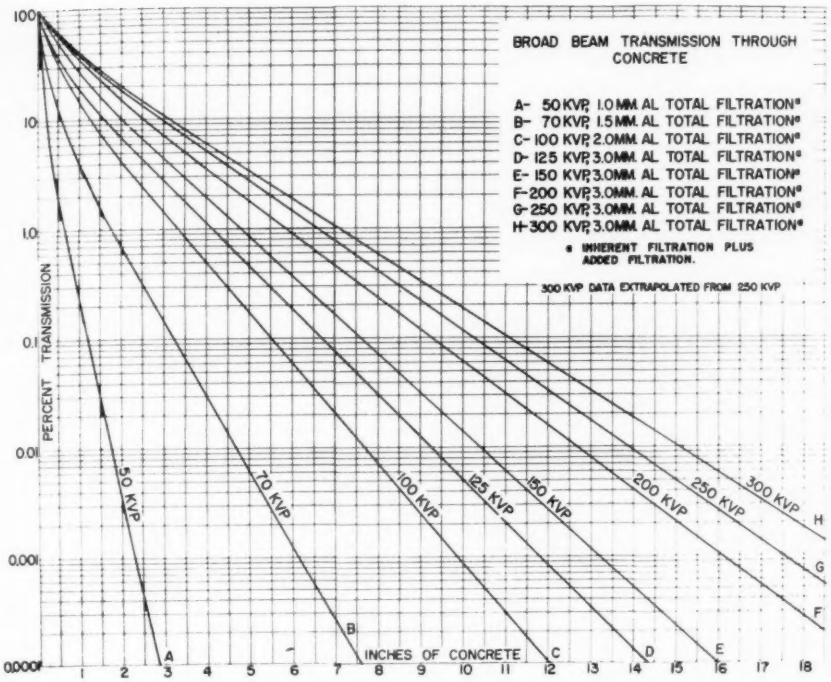

Fig. 2. Broad beam transmission through concrete.

concrete. The correction applied would take into account differences in density, atomic number, and atomic weight. The correction factor so derived would be essentially constant over a wide range of energies.

The logical material for such a study would be aluminum, which can be procured and handled in large sheets of almost any thickness. The atomic number of aluminum is 13, compared with 14 for silicon, the major element in concrete. The density for aluminum is 2.70 compared with 2.35 for concrete made to the usual 147 pounds per cubic foot specification. The atomic weight of aluminum is 26.98 and for silicon 28.09. Using these numbers, the correction factor is:

$$\frac{\frac{13}{26.98} \times 2.70}{\frac{14}{28.09} \times 2.35} = 1.11$$

Thus, for any given aluminum thickness, the equivalent concrete thickness can be obtained by multiplying the aluminum thickness by 1.11.

Convinced of the value of such information in protection planning, aluminum sheets 4 feet long, 4 feet wide, of 1/4 and 1/2 inch thickness, to a total of 10 inches, were procured. Commercial grade, 99.2 per cent pure, 2 S grade aluminum was used.

The physical arrangement was one wherein special attention was given to reducing the leakage and scattered radiation reaching the chamber from the x-ray tube and from the walls. This arrangement can best be appreciated by reference to Figure 1.

The field at the back face of the aluminum barrier was 3 3/4 feet in diameter. Chambers were placed at a distance of 6 cm. from the back surface of the barrier. The sources were 100-kvp and 250-kvp self-rectifying, half-wave x-ray machines using a 45° target and beryllium window tubes.

The ionization chambers used were

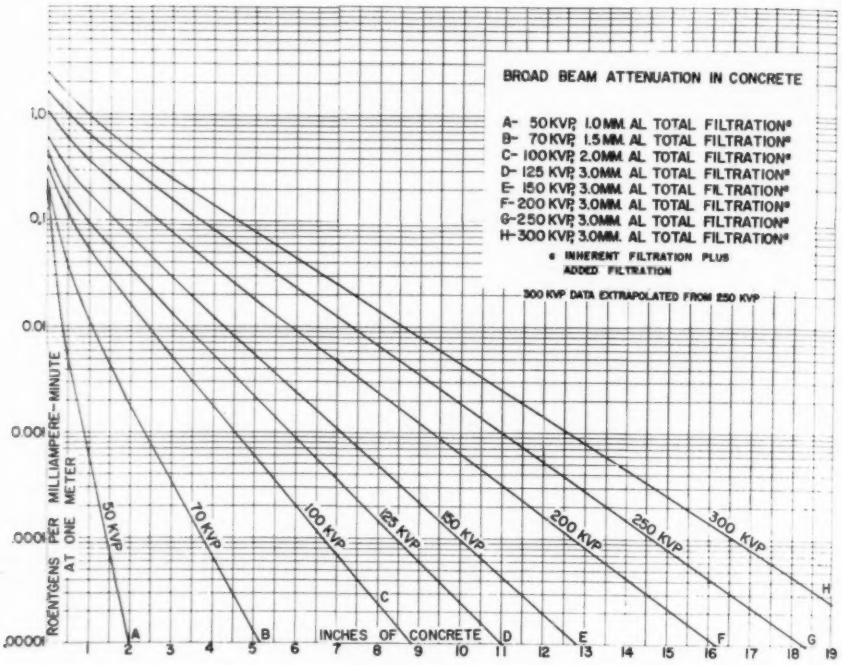

Fig. 3. Broad beam attenuation in concrete.

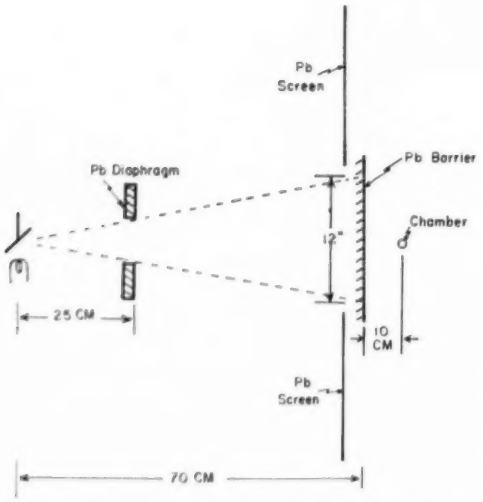

Fig. 4. Plan view of geometry for lead attenuation data.

checked against chambers previously calibrated at the National Bureau of Standards, and the necessary correction factors were applied to the data.

The voltages, total filtration, and half-value layers at which data were taken are shown in Table I. Voltages and filtrations were selected to coincide with attenuation data given by the National Committee on Radiation Protection and Measurements in NBS Handbook 60 (3).

TABLE I: VOLTAGES, FILTRATION, AND HALF-VALUE LAYERS FOR WHICH DATA WERE OBTAINED

Potential (kvp)	Total Filter (mm. Al)	Half-Value Layer (mm.)
50	1.0	0.75 Al
70	1.5	1.5 Al
100	2.0	2.5 Al
125	3.0	4.0 Al
150	3.0	0.1 Cu
200	3.0	0.2 Cu
250	3.0	0.3 Cu
300	3.0	0.5 Cu

When the original study was made, the maximum voltage available was 250 kvp. The data were extrapolated to 300 kvp. Later a 300-kvp machine became available and these values were checked and found to be in good agreement with the extrapolated data.

It has been the practice in NCRP

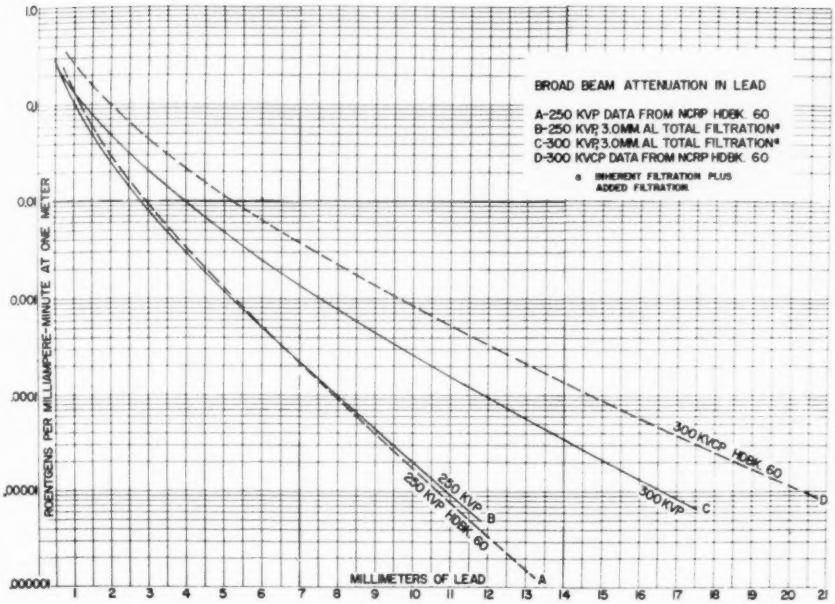

Fig. 5. Broad beam attenuation in lead.

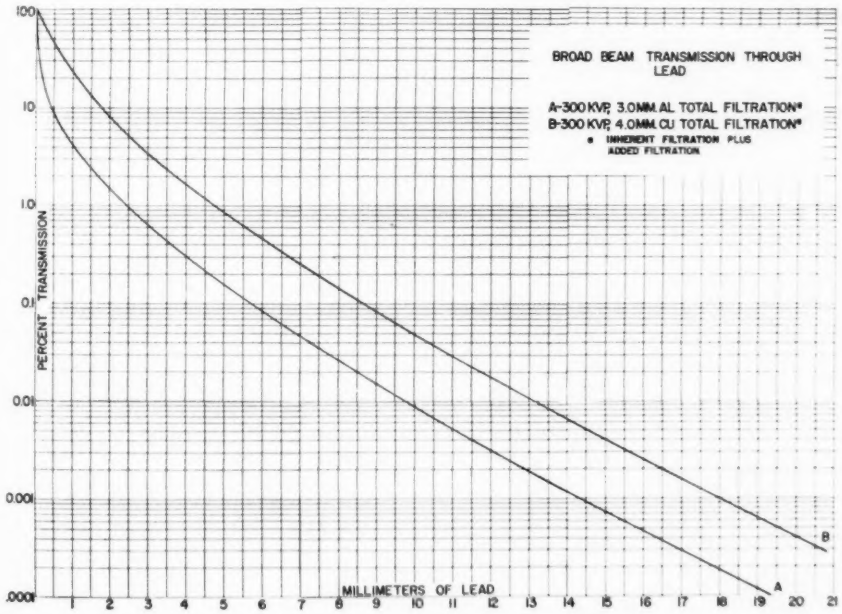

Fig. 6. Broad beam transmission through lead.

handbooks to plot attenuation data as a function of thickness *vs.* roentgens per milliampere-minute at 1 meter. There are times when a conventional transmission curve may be useful and the data are presented in both forms (Figs. 2 and 3).

One of the problems encountered by the installation planner is that of an existing

TABLE II: CONCRETE AND LEAD EQUIVALENTS

Thickness of Concrete (inches)	Potential, kvp							
	50	70	100	125	150	200	250	300
	Thickness of Lead (mm.)							
0	0	0	0	0	0	0	0	0
0.5	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2
1.0	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.4
1.5	0.3	0.4	0.4	0.4	0.4	0.5	0.5	0.5
2.0	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.7
2.5	0.6	0.7	0.8	0.7	0.7	0.8	0.9	0.9
3.0	..	0.9	0.9	0.9	0.9	0.9	1.0	1.0
4.0	..	1.2	1.2	1.2	1.2	1.2	1.3	1.4
5.0	..	1.5	1.6	1.5	1.4	1.4	1.6	1.9
6.0	..	1.9	1.9	1.8	1.7	1.7	1.9	2.4
8.0	..	..	2.7	2.5	2.4	2.5	3.0	3.7
10.0	..	..	3.4	3.2	3.0	3.2	4.2	5.4
12.0	..	..	4.2	3.9	3.7	4.1	5.6	7.1
14.0	..	..	..	4.5	4.3	5.0	6.9	9.2
16.0	..	..	..	..	5.1	5.9	8.4	11.4
18.0	..	..	..	..	..	6.9	10.0	13.6

TABLE III: HALF-VALUE LAYERS IN CONCRETE AND LEAD FOR VARIOUS VOLTAGES

Attenuating Material	Half-Value Layer for Indicated Tube Potential (kvp)							
	50	70	100	125	150	200	250	300
Lead (mm.)	0.05	0.18	0.24	0.27	0.3	0.5	0.8	1.3
Concrete (in.)	0.2	0.5	0.7	0.8	0.9	1.0	1.1	1.2

structure in which it may be desirable to add lead to an existing barrier to arrive at some desired lead equivalent for the composite barrier. In our work we have found a table of lead-concrete equivalents quite useful. Such information is presented in Table II, for which the values were derived from the straight portions of the Handbook 60 curves for lead and our curves for concrete.

Another useful table is one showing half-value layers in concrete and lead for various voltages. In the interest of completeness in a single reference, data from Handbook 60 and our additional values have been combined in Table III.

BROAD BEAM ATTENUATION DATA IN LEAD

Broad beam attenuation data in lead, published in NCRP Handbook 60, are based on pulsating wave-form sources from 50 to 250 kvp, but the data for 300 kv are based on a constant potential source. *Note g* accompanying Table 8 in Handbook 60 states that pulsating machines may require 10 to 20 per cent lesser thicknesses than those shown in the tables for 300 kvcp. When a 300-kv pulsating source became available in our laboratory, it was felt that attenuation data in lead for pulsating sources should be developed. A 1,000-cycle, self-rectifying, half-wave machine and the arrangement shown in Figure 4 were used. The field at the incident face of the barrier was 12 inches in diameter, since this is adequate for such studies for lead barriers.

Our attenuation data for 250 kvp and 300 kvp (pulsating) along with those for 250 kvp (pulsating) and 300 kv (constant potential) from Handbook 60 are shown in Figure 5. Our transmission data for 300 kvp for two filtrations are shown in Figure 6.

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SUMMARIO IN INTERLINGUA

Attenuation De Large Fasces In Beton Pro Radios X De Inter 50 E 300 kvp E In Plumbo Pro Radios X De 300 kvp

Datos relative al attenuation de large fasces in beton pro plus basse voltages (50 a 300 kvp in radios X) esseva derivate per obtener datos pro aluminio (que se manipula plus facilemente) e corriger los pro differentias de densitate, numero atomic, e peso atomic. Le resultatos del studio es presentate in le forma de duo illustrationes. Es etiam presentate illustrationes que monstra datos de attenuation e transmission de large fasces in plumbo, basate super fontes pulsante e a potential constante.

Es includite un tabula de equivalentes de plumbo e beton.

Osteomyelitis of the Mandible Following Irradiation

An Experimental Study[1]

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OSTEOMYELITIS OF the mandible following irradiation for the treatment of cancer has been recognized since 1922 (3). In spite of newer technics, including megavoltage (4), osteomyelitis is likely to remain a recurrent problem as long as portions of the mandible lie within the field of irradiation. It has been believed that the likelihood of this complication is decreased by the preliminary extraction of any teeth that are diseased or lie within the area to be irradiated. This opinion, however, has not been universal and experienced radiation therapists, such as Quick (2) and Paterson (1), have advocated postponement of extraction. More recently, Wildermuth and Cantril (5) have proposed that extraction of teeth before irradiation actually predisposes to osteomyelitis. We are reporting the results to date of a series of experiments designed to study certain features of this problem.

MATERIAL

Adult mongrel dogs were used throughout these experiments. They were housed in individual cages and were maintained on the standard kennel ration of cooked ground horse meat, rolled oats, fish oil, and tomato juice five days a week. On weekends, dry commercial dog ration reconstituted with water was substituted. Both diets were of a mushy consistency and required no chewing. This diet has been in use for many years and has been found to be nutritionally adequate. Preliminary examination of the mouth was performed to exclude animals with preexisting dental or gingival injury or abnormality.

IRRADIATION TECHNIC

X-rays of 250-kv with a half-value layer of 1.4 mm. Cu were used at 50 cm. target-skin distance. The output, which was calibrated daily, varied between 105 and 110 r (measured without back-scatter) per minute. Each side of the mandible was treated through a single lateral field measuring 5 × 5 cm. The anterior margin of the field coincided with the anterior margin of the fourth premolar and extended back onto the ramus of the mandible. The entire superior-inferior width of the mandible was encompassed by the field. A lead shield, 3 mm. thick, was placed on the lingual side of the mandible, protecting the tongue and the opposite side of the jaw. A second lead shield was used to demarcate the anterior margin of the irradiated area in addition to the treatment cone. The animals were irradiated every other day, three days a week, for an overall period of fifteen days. The right and left sides of the mandible were irradiated identically on each occasion. The total amount of radiation to each side ranged from 3,000 to 8,000 r, measured in air.

FIRST EXPERIMENT

The first experiment was designed to determine whether osteomyelitis could be produced, and at what dose level, under the experimental conditions. Eight dogs were used. The total amount of radiation delivered ranged from 3,000 to 8,000 r (air) in 1,000 r increments. The acute radiation reaction observed corresponded to that seen clinically. A moist epidermitis promptly developed, together with epilation and depigmentation of the skin in the treatment

[1] From the Department of Radiology (Dr. Robert S. Stone, Chairman), University of California School of Medicine, San Francisco, Calif. Presented at the Forty-third Annual Meeting of the Radiological Society of North America, Chicago, Ill., Nov. 17–22, 1957.

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[3] Trainee, National Cancer Institute.

[4] Department of Pathology, University of California School of Medicine, San Francisco.

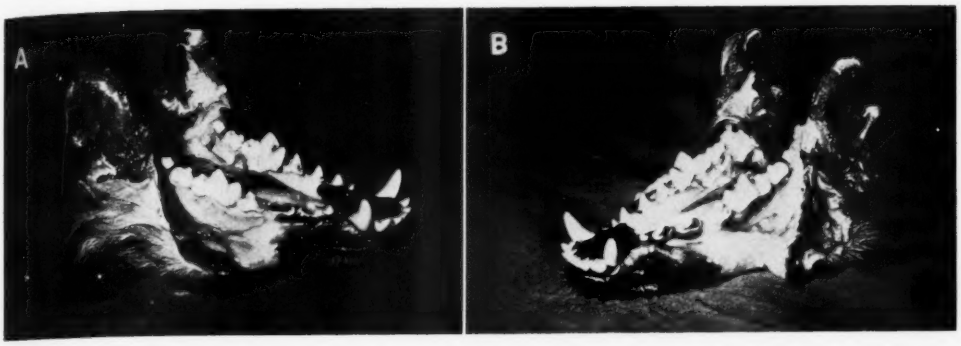

Fig. 1. Bilateral ulceration and osteomyelitis following 5,000 r. Depigmentation and edema of the buccal mucosa in treated areas is noted. Definite resorption of alveolar bone about the necks of the teeth (Dog 185).

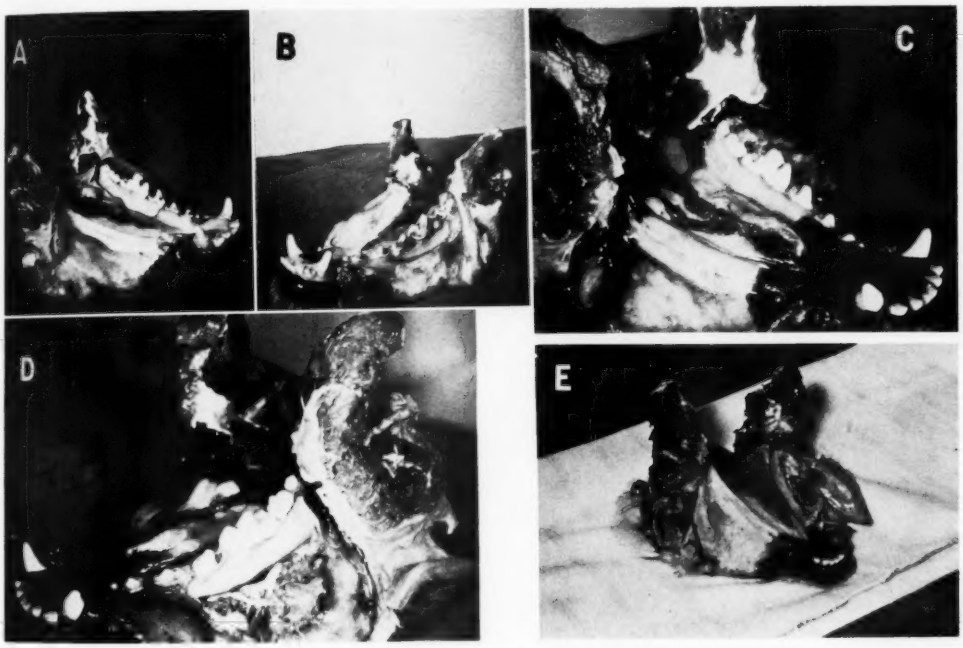

Fig. 2. Ulceration and osteomyelitis following irradiation of the tooth-bearing side of the mandible with intact mucosa over the nontooth-bearing side of the mandible.
A and B. 5,000 r (Dog 157). C and D. 5,000 r (Dog 16). E. 6,000 r. Extensive resorption of alveolar bone with exfoliation of teeth on left (Dog 62).

area. The irradiated mucous membranes showed a pseudomembranous mucositis with depigmentation and moderate edema. The acute reaction subsided in twenty to thirty days in the animals receiving 3,000 and 4,000 r. There were residual depigmentation and minimal atrophy, but no telangiectasia or ulceration. In the animals receiving 5,000 r and more, the acute radiation reaction subsided in thirty to forty days, with residual edema and hemorrhagic gingivitis about the margins of the teeth. Recession of the gingival margin then occurred, with eventual ulceration exposing the necks of the teeth and adjacent portions of the mandible. The process was rapidly progressive and resulted in loosening of the teeth, development of

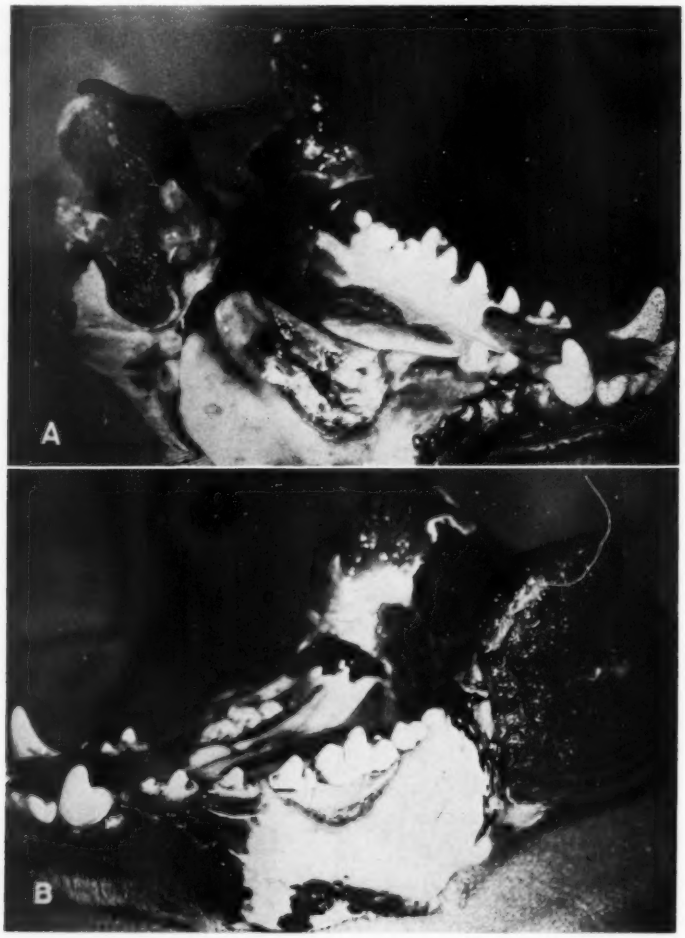

Fig. 3. Ulceration and osteomyelitis following irradiation, affecting both the tooth-bearing and nontooth-bearing sides of the mandible; 4,000 r (Dog 75).

sinus tracts about the body of the mandible, and occasionally the formation of orocutaneous fistulae. The delayed reaction reached its end point fifty to seventy-five days following irradiation. No difference was noted between the right and left sides of the mandible, which received identical doses (Table I).

SECOND EXPERIMENT

The second experiment was designed to study the effect of extraction of the teeth prior to irradiation. A standard surgical procedure was adopted, consisting of extraction of the molars and premolars on the right side of the mandible, combined with an extensive alveolectomy and primary closure of the mucosa. The operation was performed on an average of sixteen days prior to irradiation (range seven to twenty-eight days). All surgical procedures were performed by the same surgeon (F. W. C.). Both sides of the mandible were subsequently irradiated according to the schedule described in the first experiment.

On the tooth-bearing side of the mandible, soft-tissue ulceration and osteomyelitis occurred in all the animals with the exception of dog 195, which received 3,000 r, and dog 105, which received 4,000 r. The

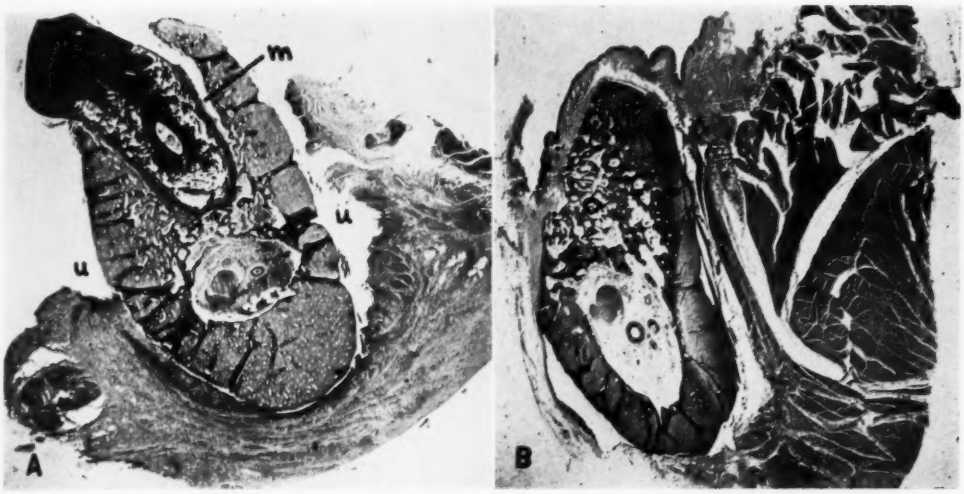

Fig. 4. Cross sections of the mandible (low magnification).
A. Tooth-bearing mandible following irradiation with 6,000 r, with deep ulcerations of the soft tissues (u), destruction of the periodontal membrane (m), and diffuse osteomyelitis (Dog 80).
B. Nontooth-bearing mandible following irradiation with 5,000 r, with intact mucosa and almost complete reconstruction of the alveolus by new, actively proliferating osseous tissue (o). No evidence of osteomyelitis (Dog 76).

TABLE I: RESULTS OF IRRADIATION OF THE TOOTH-BEARING MANDIBLE

Dog No.	Radiation Dosage	Left Mandible		Right Mandible		Comments
		Ulceration	Osteomyelitis	Ulceration	Osteomyelitis	
120	3,000 r	0	0	0	0	Alive and well 2 years
134	4,000 r	0	0	0	0	
83		0	0	0	0	Mucosa intact for 75 days but ulcerated following delayed dental extraction with development of osteomyelitis
82	5,000 r	4+	4+	4+	4+	
183		4+	4+	4+	4+	
84	6,000 r	4+	4+	4+	4+	
58	7,000 r					Anesthetic death during course of treatment
60	8,000 r	4+	4+	4+	4+	

acute and delayed reactions corresponded to those in the earlier experiment, with the additional observation that ulceration and osteomyelitis developed in 3 of 4 dogs exposed to a dose of 4,000 r.

On the edentulous side of the mandible, soft-tissue ulceration and osteomyelitis developed in 3 animals. Two had received 4,000 r and the other 8,000 r. Two instances of superficial ulceration of soft tissue were noted, both in dogs receiving 6,000 r. In 1 animal the soft-tissue ulceration began at the angle of the mouth and progressed on to the gingiva overlying the mandible. In the other dog the ulceration developed directly on the alveolar ridge. These areas were closely examined histologically and showed no osteomyelitis of the underlying mandible.

The overall results are given in Table II. In 12 of 14 hemimandibles in which the teeth were present osteomyelitis developed as contrasted to 3 of 14 hemimandibles from which the teeth had been removed prior to irradiation. The probability of this difference occurring in this number of animals due to chance alone is less than 5 per cent.

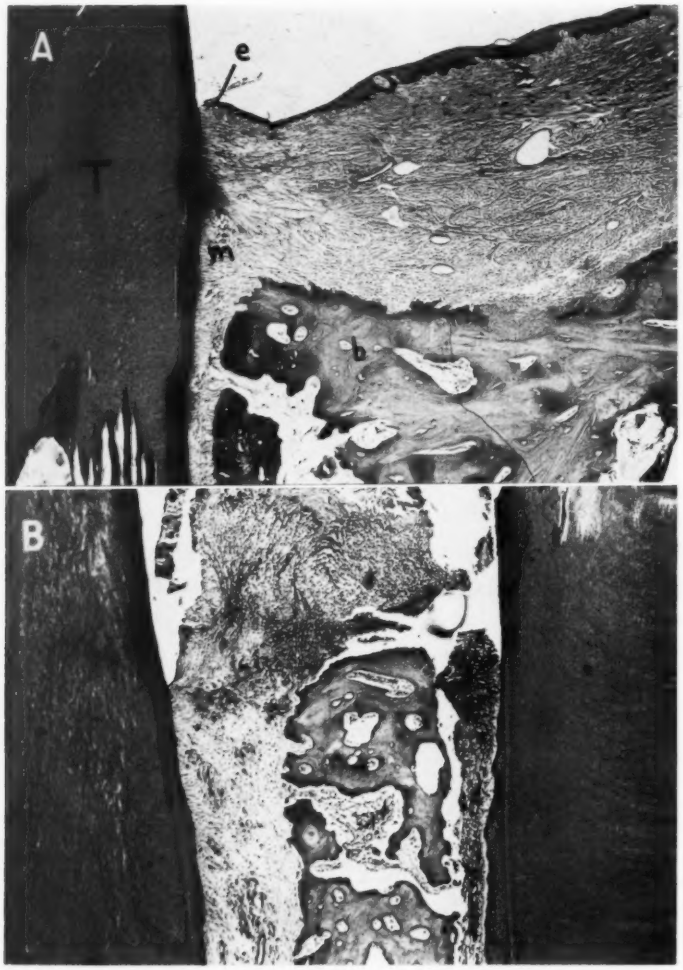

Fig. 5. Comparison of normal and irradiated interdental cervical areas of the mandible (high magnification).

A. Normal thin epithelial attachment (e) to the periodontal membrane at the neck of the tooth (T). Intact alveolar bone (b) and periodontal membrane (m).

B. 6,000 r. Destruction of interdental epithelium with purulent exudate extending into periodontal membrane and medullary space of the alveolar bone (Dog 84).

MICROSCOPIC FINDINGS

Autopsy material from 21 dogs was examined. The salient findings were as follows:

1. In the soft tissues about the teeth there was a massive necrotizing cellulitis which had dissected along the periosteum over the superior, lateral, and mesial aspects of the mandibular cortex.

2. Osteomyelitis was not observed in the absence of ulceration of the overlying soft tissue.

3. All mandibles, including those receiving an air dose of 8,000 r, showed evidence of actively proliferating osteoid tissue. In no instance was there microscopic evidence of bone necrosis unassociated with osteomyelitis.

4. The osteomyelitis was limited to the general area of irradiation.

Fig. 6. Comparison of normal and irradiated apical areas (high magnification).
A. Normal. Note orderly arrangement of alveolar bone (b), periodontal membrane (m), cementum (c), dentin (d), and pulp (p).
B. 5,000 r. Inflammatory exudate about apex of tooth involving periapical periodontal membrane. Note intact periodontal membrane more distally. Inflammatory exudate about alveolar bone with active proliferation of new bone (n) (Dog 185).

The sequence of events in the development of osteomyelitis based on pathologic findings was as follows:

1. Ulceration of gingiva.
2. Extension of the inflammation into the periodontal membrane and through the lamina dura to involve the medullary cavity of the mandible and apices of the teeth.
3. Further destruction of the periodontal membrane with exfoliation of teeth.

CONCLUSION

1. A generally applicable method is described for the experimental irradiation of the mandible of the adult dog.
2. Gingival ulceration and osteomyelitis of the underlying mandible occurred following exposure to irradiation of 4,000 r (air) or more, under the conditions of this experiment.

TABLE II: RESULTS OF IRRADIATION FOLLOWING PRELIMINARY DENTAL EXTRACTION

Dog No.	Radiation Dosage	Left Mandible (Tooth-Bearing)		Right Mandible (Non Tooth-Bearing)	
		Ulceration	Osteomyelitis	Ulceration	Osteomyelitis
195	3,000 r	0	0	0	0
75	4,000 r	2+	2+	4+	4+
188		4+	4+	0	0
18		4+	4+	0	0
105		0	0	3+	4+
76	5,000 r	4+	4+	0	0
77		3+	2+	0	0
157		4+	4+	0	0
16	6,000 r	4+	4+	1+	0
62		4+	4+	0	0
80		4+	4+	1+	0
48	7,000 r	4+	4+	0	0
78		3+	2+	0	0
52	8,000 r	4+	2+	2+	2+

3. Removal of the teeth prior to irradiation of the mandible significantly decreased the incidence of osteomyelitis.

4. Osteomyelitis was not observed in the absence of ulceration of the overlying gingiva.

5. Bone necrosis without osteomyelitis was not observed with the dosage and time range studied.

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SUMMARIO IN INTERLINGUA

Osteomyelitis Del Mandibula Post Irradiation: Un Studio Experimental

Esseva effectuate un studio experimental pro determinar le effecto que extractiones dental sequite per irradiation exerce super le disveloppamento subsequente de osteomyelitis del mandibula.

Es describite un generalmente applicabile methodo pro le irradiation experimental del mandibula de canes adulte. Con le uso de iste methodo, ulceration gingival e osteomyelitis del subjacente mandibula occurreva post exposition a doses de irradiation de 4.000 r (in aere) o plus. Le extraction del dentes ante le irradiation reduceva significativemente le incidentia de osteomyelitis.

Osteomyelitis non esseva observate in le absentia de ulceration del suprajacente gingiva. Necrose de osso non occurreva con le dosage e le tempores de exposition studiate.

The Nature of the Effect of ACTH and Cortisone on Tumor Growth in Irradiated Animals[1]

HENRY P. PLENK, M.S., M.D., ROGER FUSON, M.S., and FRED M. SORENSEN, B.S.

THE ANTI-INFLAMMATORY effect of ACTH suggested its use for suppressing skin reactions in man following irradiation. It was shown that severe skin reaction due to x-radiation could be avoided or, if present, made to abate more rapidly by means of ACTH (25 mg./day) than by other forms of treatment.

Since cortisone enhanced the lethal effect of x-rays (4) and increased the incidence of metastases of some experimental tumors (1, 2), a study of the mutual effect of these compounds and irradiation on experimental tumors seemed advisable.

MATERIAL AND METHODS

The following tumors and strains of mice were used:

1. C-1300 (neuroblastoma) in ABC mice
2. 15091-a (mammary carcinoma) in ABC mice
3. E 0771 (mammary carcinoma) in C57 Bl mice

Transplantation of tumor fragments into the anterior chamber of the right eye of these strains produced almost 100 per cent "takes." Under Nembutal anesthesia a dose of 3,000 r in air was administered through a 0.8-cm. field to the right orbit on the fourth day after transplantation. The factors were 140 kvp, 10 ma, no filter, 21 cm. focal skin distance, 461 r/min./air, h.v.l. 1.28 mm. Al.

ACTH, 0.5 mg. dissolved in distilled water, or cortisone, 0.25 mg., was administered daily intraperitoneally. Administration of both drugs was started after tumor inoculation but prior to irradiation and was continued for fourteen, twenty, or forty-five days. Terramycin, 0.25 mg./ml., was added to the drinking water. Animals dying prior to the twenty-

Fig. 1. Appearance of mice after tumor transplantation into anterior chamber of right eye: A. Three days after tumor inoculation. B. Thirty-five days after tumor inoculation, no treatment. C. Thirty-five days after tumor inoculation, x-ray therapy on fourth day after transplantation.

[1] From the Department of Radiology, St. Mark's Hospital, and the University of Utah Medical School, Salt Lake City, Utah. Presented at the Forty-third Annual Meeting of the Radiological Society of North America, Chicago, Ill., Nov. 17–22, 1957.

This investigation was supported by the American Cancer Society and the James Picker Foundation on recommendation of the Committee on Radiology, National Research Council.

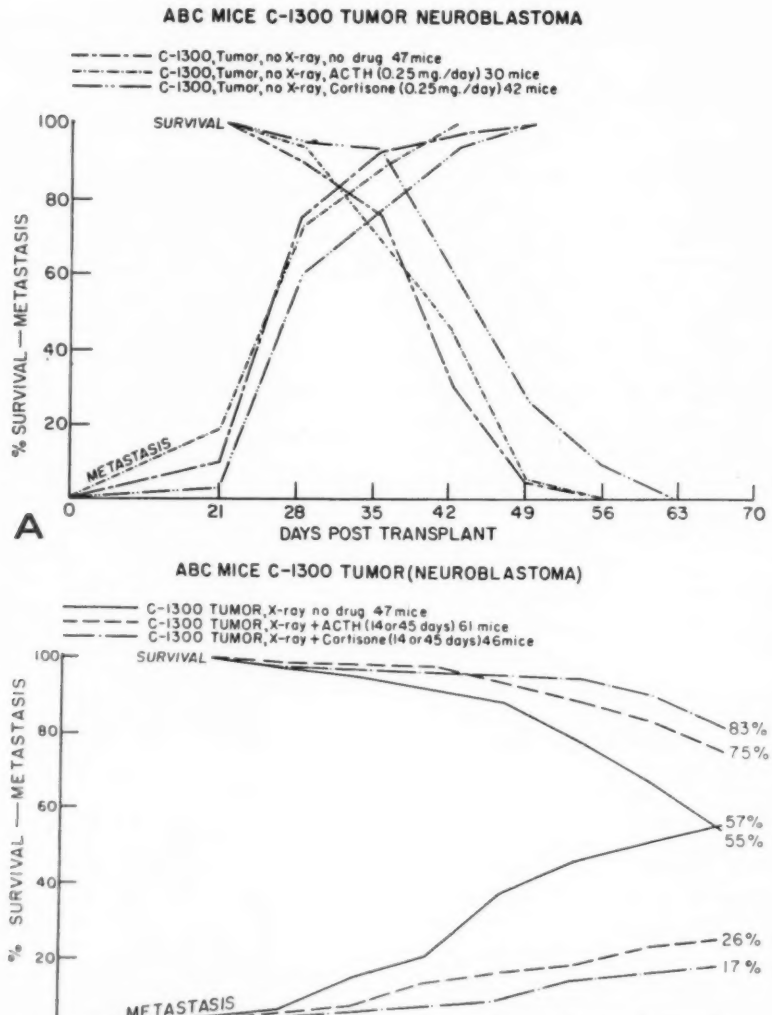
ABC MICE C-1300 TUMOR NEUROBLASTOMA
C-1300, Tumor, no X-ray, no drug 47 mice
C-1300, Tumor, no X-ray, ACTH (0.25 mg./day) 30 mice
C-1300, Tumor, no X-ray, Cortisone (0.25 mg./day) 42 mice
SURVIVAL
METASTASIS
% SURVIVAL — METASTASIS
DAYS POST TRANSPLANT
A
ABC MICE C-1300 TUMOR (NEUROBLASTOMA)
C-1300 TUMOR, X-ray no drug 47 mice
C-1300 TUMOR, X-ray + ACTH (14 or 45 days) 61 mice
C-1300 TUMOR, X-ray + Cortisone (14 or 45 days) 46 mice
83%
75%
57%
55%
26%
17%
B

Fig. 2. Effect of ACTH and cortisone on the incidence of metastases and survival of (A) unirradiated and (B) irradiated ABC mice following inoculation of C-1300 tumor.

first day after transplantation as the result of the operation were discarded in the analysis of results.

The tumor can be seen readily in the anterior chamber at three days after transplantation (Fig. 1, A). In unirradiated animals progressive tumor growth involves the orbit and often spreads into surrounding facial tissues by contiguity (Fig. 1, B). Only one tumor (C-1300) metastasizes regularly to the cervical lymph nodes. Irradiated animals reveal an area of alopecia around the orbit. The eye is usually cicatrized (Fig. 1, C). Recurrent tumor growth becomes apparent usually after the thirty-fifth day and leads to death prior to the seventieth day. Most animals which survive the period of observation are free of tumor.

X-ray administration resulted in sur-

TABLE I: SUMMARY OF RESULTS: EFFECT OF ACTH AND CORTISONE ON SURVIVAL OF MICE AND INCIDENCE OF METASTASIS FOLLOWING X-RAY THERAPY AFTER TRANSPLANTATION OF TUMORS INTO THE ANTERIOR CHAMBER OF THE EYE IN MICE

Tumor and Strain	No X-Ray No Drug	X-Ray Only	X-Ray and ACTH	X-Ray and Cortisone
C-1300, ABC mice	47	47	61	46
70-day survival	0	26 (55%)	46 (75%)	38 (83%)
Incidence of metastases	47 (100%)	27 (57%)	16 (26%)	8 (17%)
15091-a, ABC Mice	42	40	40	40
70-day survival	0	9 (23%)	21 (52%)	15 (37%)
E 0771, C57 Bl Mice	13	46	46	44
70-day survival	0	21 (46%)	23 (50%)	32 (73%)

vival of 23 to 55 per cent of mice for seventy days. The time and dose factors of irradiation were chosen to allow observation of the effectiveness of drugs in producing either an increase or decrease in the number of seventy-day survivors (6).

RESULTS

C-1300 in ABC Mice: C-1300 was the only tumor that metastasized regularly to the cervical lymph nodes in animals with persistent primary tumor growth in the orbit. All 47 control animals were dead by the fifty-sixth day. Though a few animals given cortisone survived up to the sixty-third day, neither cortisone nor ACTH produced any significant change in the survival time of unirradiated animals (Fig. 2 A).

Following irradiation, 55 per cent of the animals survived for seventy days. The addition of cortisone or ACTH increased the seventy-day survival to 83 and 75 per cent, respectively (Fig. 2 B).

In all untreated animals inoculated with tumor C-1300 cervical metastases developed. Fifty-seven per cent of irradiated mice also revealed cervical lymph node enlargement. ACTH and cortisone did not influence the incidence of metastases in unirradiated animals (Fig. 2, A). When administered to irradiated mice, the drugs reduced the incidence of cervical metastases to 26 and 17 per cent respectively (Fig. 2, B).

The difference in survival between the irradiated control group and the groups receiving ACTH plus irradiation and also cortisone and irradiation is significant ($P = 0.05 - 0.02$, $P<0.01$, respectively). Since no significant difference was observed between the groups receiving ACTH and cortisone for fourteen or forty-five days, the data for these groups were combined.

15091-a in ABC Mice: Inoculation of tumor 15091-a into ABC mice resulted in death of all unirradiated control animals by the forty-second day. The administration of cortisone or of ACTH without irradiation had no effect on the survival time. Irradiation produced seventy-day survival of 23 per cent of the control animals. Thirty-seven per cent of the animals receiving cortisone also and 52 per cent of the animals receiving ACTH for a period of fourteen days beginning the day following tumor transplantation survived seventy days (Table I). The difference in survival between irradiated control animals and those treated also with ACTH was highly significant ($P = 0.02 - 0.01$); cortisone treatment followed the same trend ($P = 0.20 - 0.30$) (Fig. 3 and Table I).

E 0771 in C57 Bl Mice: All unirradiated control animals inoculated with tumor E 0771 were dead within fifty-six days. Some unirradiated animals receiving ACTH and cortisone survived up to sixty-four days, but all died within seventy days. Irradiation resulted in seventy-day survival of 46 per cent of the animals. Administration of ACTH or cortisone increased the survival rate to 50 and 73 per cent, respectively.

The difference in survival rate of the irradiated control group and the group receiving x-rays plus ACTH is insignificant ($P = 0.80 - 0.90$), but the difference between the irradiated controls and the mice receiving x-rays plus cortisone is highly significant ($P = 0.02 - 0.01$) (Fig. 4 and Table I).

DISCUSSION

In our study neither ACTH nor cortisone alone affected the survival rate of unirradiated mice with tumor implants in the anterior chamber of the eye; nor was any effect observed on the incidence of metastases of one tumor. Both drugs, however, enhanced the effect of x-rays in increasing the survival rate and in decreasing the incidence of metastases.

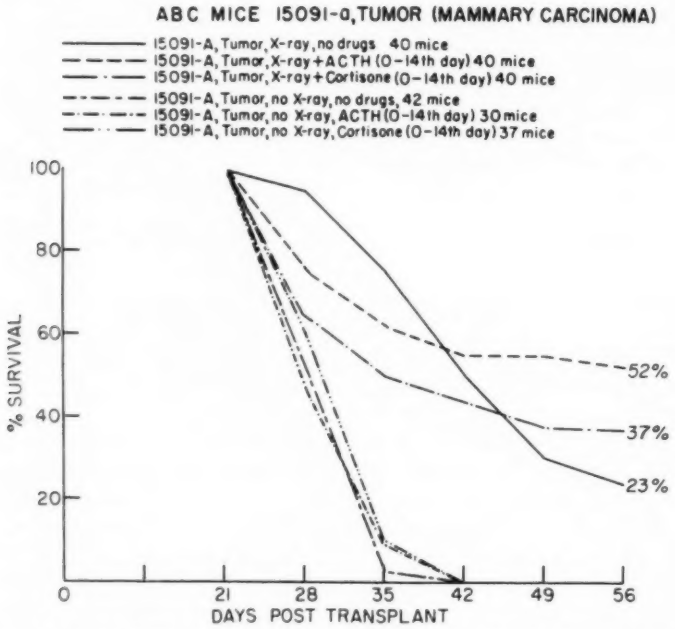

Fig. 3. Effect of ACTH and cortisone on the survival of irradiated ABC mice following inoculation of tumor 15091-a.

We must assume that the action of the two drugs was not on tumor growth *per se* but that it represents a decrease in the radioresistance of the tumors. This in turn may be due to bolstering of the defense reaction of the surrounding normal tissue to tumor growth, or it may be attributable to selective chemical or physical effect on the tumor cell.

Dougherty and Schneebeli (3) have suggested that adrenocortical hormones exert an antiphlogistic effect by enhancing the resistance of surviving non-injured cells to the cytotoxic action of the inflammatory agent. Eyring and Dougherty (5) have also advanced the hypothesis that the antiphlogistic hormones act by preventing cellular destruction by stabilizing the impermeable state of the cell membrane. Our observations are quite consistent with this hypothesis. Stabilization of the impermeability of the cell membrane may be more disastrous to the actively metabolizing cancer cell than to the relatively quiescent surrounding connective-tissue cells following exposure to x-rays. This may be the way in which the difference in radiosensitivity between the normal and cancer cell is widened, resulting in greater inhibition of tumor growth by x-rays.

SUMMARY AND CONCLUSIONS

1. Two mammary carcinomas (15091-a and E 0771) and one neuroblastoma (C-1300) were transplanted into the anterior chamber of the eye in young mice of susceptible strains.

2. A single administration of 3,000 r/air to the orbit on the fourth post-

transplant day produced survivals at seventy days of 23 to 55 per cent of the mice. Most unirradiated control animals were dead by the fifty-sixth day.

3. The administration of ACTH or of cortisone in association with irradiation for at least fourteen days after transplantation resulted in an increase in the dence of metastases in unirradiated animals.

7. ACTH and cortisone enhanced the inhibitory effect of x-rays on tumor growth without ill effects on the tumor-bearing animal.

8. It is believed that the influence of these hormones on the prolongation of life and on the decreased incidence of

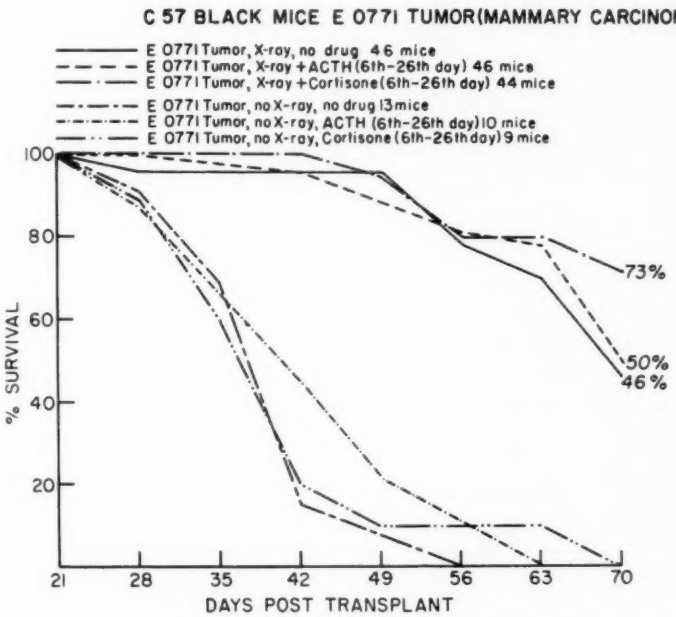

Fig. 4. Effect of ACTH and cortisone on the survival of irradiated C 57 mice following inoculation of tumor E 0771.

seventy-day-survival rate in both strains of mice with all three tumors used in this experiment.

4. Cortisone was more effective than ACTH in two tumors (C-1300 and E 0771). ACTH was more effective than cortisone in one tumor (15091-a).

5. In the only tumor (C-1300) which metastasizes regularly to the cervical lymph nodes, ACTH and cortisone when administered to irradiated mice produced a significant decrease in the incidence of metastases.

6. Administration of ACTH and cortisone produced no significant inhibitory or enhancing effect on tumor growth in the anterior chamber of the eye or on the incimetastases in irradiated tumor carriers is due to a modification of the irradiation effect and not to direct action on tumor growth.

ACKNOWLEDGMENT: We are indebted to Dr. E. J. Eichwald for his continued guidance and constructive criticism. Dr. Charles Woolf, Department of Biology, University of Utah, subjected the data to statistical analysis.

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SUMMARIO IN INTERLINGUA

Le Natura Del Effecto De ACTH E De Cortisona Super Le Crescentia De Tumores In Animales Irradiate

Duo carcinomas mammari (15091-a e E 0771) e un neuroblastoma (C-1300) esseva transplantate in le camera anterior del oculo de juvene muses de racias susceptible. Un sol administration de 3.000 r/aere al orbita, le quarte die post le transplantation, resultava in un superviventia de septanta dies in inter 23 e 55 pro cento del muses. Le majoritate del non-irradiate animales de controlo esseva morte ante le cinquanta-sexte die.

Le administration de ACTH o de cortisona in association con le irradiation e durante al minus dece-quatro dies post le transplantation resultava in un augmento del cifra de superviventia post septanta dies in ambe racias de muses e con omne le typos de tumor usate in iste experimento. Cortisona esseva plus efficace que ACTH in le tumores C-1300 e E 0771. ACTH esseva plus efficace que cortisona in le tumor 15091a.

In le sol del tres tumores le qual resulta regularmente in metastases al cervical nodos lymphatic (i.e. C-1300), le administration de ACTH e cortisona a muses tractate con irradiation produceva un reduction significative in le incidentia de metastases.

In animales non-irradiate, le administration de ACTH e cortisona non habeva un significative effecto inhibitori o promotori super le crescentia del tumores in le camera anterior del oculo o super le incidentia de metastases.

ACTH e cortisona promoveva le effecto inhibitori del radios X super le crescentia de tumores sin evocar responsas adverse in le animales hospites del tumores.

Es opinate que le influentia de iste hormones super le prolongation del vita e super le reducite incidentia de metastases in irradiate portatores de tumores se explica per un modification del effecto de irradiation e non per un action directe super le crescentia del tumor.

Effects of Concomitant Superficial X-Radiation Upon the Lethal Effectiveness of 250-kvp X-Rays

EDWARD L. ALPEN and D. M. JONES[2]

A CONSISTENT AND as yet inadequately solved problem of radiation dosimetry is that of predicting the biological effect of ionizing radiation in a system wherein a homogeneous dose distribution has not been achieved. Various compromise dose measurements such as the exit dose (1, 2) or the midline tissue dose (3) have been applied and have been shown to be of only limited usefulness. For the end-point of lethality in mammals the dose which probably reflects the biological damage most directly is that which is absorbed within bone marrow. If this is true, radiation not capable of penetrating the shielding bony structures cannot accomplish biological damage that would contribute to acute lethality. It was the purpose of the study to be reported here to test the foregoing hypothesis by concomitant administration of a massive dose of soft x-rays and 250-kv x-irradiation, and simultaneously to determine the lethal dose for the 250-kvp x-rays.

METHODS

Mongrel male dogs weighing initially 8 to 12 kg. were used in all experiments. Prior to radiation exposure they were kept in isolated receiving runs for a minimum two-week quarantine period. During this interval they were dewormed and immunized against distemper and hepatitis. They were then transferred to individual cages in a controlled-environment animal room for one week before exposure and carefully observed for signs of ill health. They were weighed daily prior to and after exposure. Lethality was accounted for forty-five days following exposure. Animals were randomly assigned to treatment groups. They were irradiated under light pentobarbital anesthesia while held suspended in canvas slings.

Combined exposure animals received either 1,000 r or 3,000 r in air of 50-kvp radiation. The 50-kvp source was a Picker "Zephyr" x-ray unit equipped with a Machlett OEG-60 beryllium-window tube. Operation was at 50 kvp, 40 ma, with a 0.25-mm. aluminum filter. Under these conditions the initial h.v.l. was 0.16 mm. Al. The animals were reversed midway in the exposure interval to accomplish bilateral exposure. The distance from the target to the animal's midline was 115 cm. Under these conditions the dose rate, in air, measured at the midline distance of the dog, was 48 r/minute. Measurements of dose rates, in air, for the low-energy source were made with a Victoreen condenser r-meter. The chamber used was a factory-calibrated thin nylon wall type.

The 250-kvp exposures were made with a General Electric 250-kvp Maxitron operated at 25 ma. No filtration was added, but inherent tube filtration in this machine as used by us is relatively heavy. The initial h.v.l. in copper is 1.8 mm. The ultimate h.v.l. is 2.7 mm. The dose rate to the potential midline of the dog at 115 cm. from the target was 11.8 r/min. Dose rate measurements were made with a Bureau of Standards calibrated Victoreen condenser r-meter and 25-r thimble.

Depth dose measurements were made in both water and tissue-equivalent wax phantoms. Phantom dose measurements were made with Sievert miniature ionization chambers which had been previously

[1] From the U. S. Naval Radiological Defense Laboratory, San Francisco 24, Calif. Accepted for publication in April 1958.

The opinions or assertions contained herein are those of the writers and are not to be construed as official or reflecting the views of the Navy Department or the Naval Establishment at large.

[2] Harvard Medical School, Cambridge, Mass.

TABLE I: LD 50 FOR 250-KVP RADIATION IN DOGS PREVIOUSLY IRRADIATED WITH 50-KVP X-RAYS

Treatment	LD 50 (roentgens in air) for 250 kvp Only	Slope (b) of the Probit-Log Dose Regression
250 kvp only	275 r ± 5 r*	21.9
250 kvp after 1,000 r 50 kvp	226 ± 9	17.3
250 kvp after 3,000 r 50 kvp	205 ± 7	6.9

* Standard error of estimate for LD 50.

calibrated in air with Co^{60} radiation. A lateral dimension of 16 cm. parallel to the radiation beam was used to simulate the average dog. The midline-to-surface dose ratio was also measured with the Bakelite and nylon wall Victoreen chambers. Values for this ratio differed by only 4 per cent from the Sievert chamber value for radiation of either quality.

Immediately after receiving the 50-kvp radiation, the dogs were exposed to graded doses of 250-kvp radiation. The doses used were: for animals receiving no 50-kvp radiation 260 r, 280 r, 300 r, and 320 r; for those receiving 1,000 r of 50-kvp radiation, 180 r, 200 r, 220 r, and 240 r; for those receiving 3,000 r of 50-kvp radiation, 160 r, 180 r, 200 r, and 220 r. The experiment was performed in replication, with one animal representing each dose of each treatment included in each replication. Seven complete replications were made for the two groups receiving additional superficial radiation and an additional three replications were made for the dogs receiving 250 kvp only, giving a total of ten animals per dose level in this latter group.

RESULTS

The mortality data were analyzed by the method of maximum likelihood to arrive at estimates of the LD 50 and the slope of the probit regression line. Table I presents the results of the analysis made when only the 250-kvp radiation is considered. This calculation is of value to show the maximum effect that can be expected from the superficial radiation, as no corrections are applied for the fraction of this softer radiation which might penetrate to deeper tissues.

The exposure to 1,000 r or to 3,000 r of 50-kvp x-radiation, delivered bilaterally, has reduced the dose of 250-kvp radiation required to kill by a statistically significant amount in both treatment groups, as compared with 250 kvp only but, considering the magnitude of the superimposed superficial radiation, this effect is small. For 1,000 r an apparent contribution of only 49 r or 4.9 per cent of the administered air dose can be seen, and for 3,000 r an apparent contribution of 70 r or 2.3 per cent of the administered air dose.

Clinical observation of the animals during the postexposure period showed no significant difference between those groups receiving concomitant superficial radiation and the 250-kvp-only group. No significant skin lesions developed other than moderate epilation in the highest dose group. This epilation appeared in the second postexposure week. Survival times also showed no variation with treatment.

TABLE II: MEAN POSTIRRADIATION SURVIVAL FOR DECEDENTS

Treatment	Survival Time (days)
250 kvp	12.6 ± 6.5
250 kvp + 1,000 r 50 kvp	18.8 ± 3.9
250 kvp + 3,000 r 50 kvp	17.8 ± 6.3
Pooled mean	16.2 ± 5.9

Table II shows the average survival times for the decedents in each of the three groups. No significant differences among the treatments can be observed, and the pooled estimate of survival time, 16.2 days, agrees favorably with previous experience in this laboratory (4).

Tissue-equivalent wax phantom measurements of volume distribution of dose are shown in Figs. 1 and 2 for the two qualities of radiation used under conditions identical with those for animal exposures.

DISCUSSION

The data shown in Table I indicate the LD 50 in terms of the air dose of 250-kvp x-rays only, without consideration of the

contribution to either air dose or tissue dose of the softer component. With the marked deviation of the tissue depth dose distribution from homogeneity that one predicts with the addition of the soft component (Fig. 2), it becomes a difficult problem to describe quantitatively the contribution from this lower-energy radiation. Several approaches have been suggested, of which the now well known volume dose or integral dose concept of

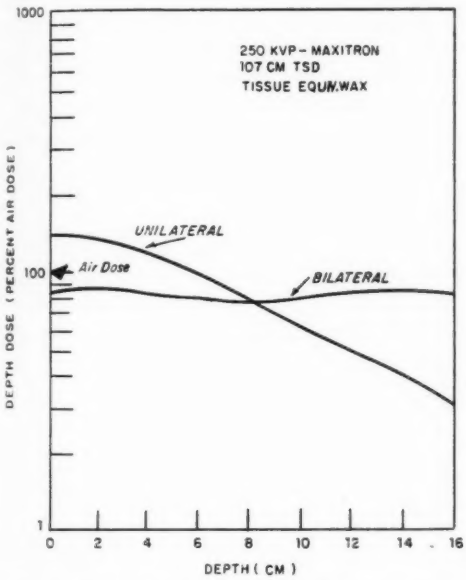

Fig. 1. Depth dose distribution in tissue-equivalent wax for 250-kvp radiation.

Mayneord (5) has received the widest attention and use. Grahn, Sacher, and Walton (6) have tested this concept in rabbits and mice and have found that it fails to correct for difference in biological effectiveness of various x-ray qualities. Because of general agreement that the integral dose concept has failed to express adequately biological effectiveness of ionizing radiation, Bond *et al.* (3) have recommended, as an alternative approach, that the midline tissue dose be used to characterize bilateral exposures such as those used in the present studies. In so far as this dose measurement succeeds in estimating biological effectiveness, it is a useful con-

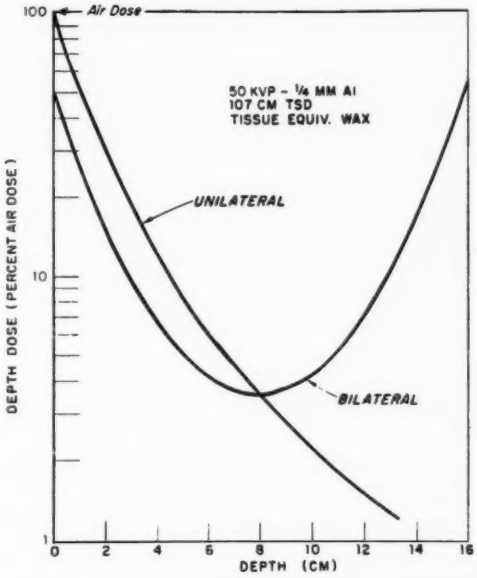

Fig. 2. Depth dose distribution in tissue-equivalent wax for 50-kvp radiation.

vention of dose measurement for describing biological effects of inhomogeneous tissue dose distributions, but care must be observed that biological significance greater than is merited does not become associated with the concept. The critical organ for lethality is obviously not located at the midline of the animal, and a combination of circumstances leads to the general success of the dose at this point as a measurement of biological effectiveness.

We have previously shown (4), as have Grahn, Sacher, and Walton (6), that the midline tissue dose fails at lower x-ray energies. For x-ray energies above 250 kvp, however, and for other radiations such as neutrons, where bone attenuation is of lesser importance, the tissue dose measured at the midline has extensive usefulness. It is particularly valuable in predicting biological effects where whole-body dose distribution patterns are distorted by geometrical considerations. Part of the success of the midline dose depends upon the balancing out of bone attenuation in generally more superficial bone-marrow sites against soft-tissue attenuation to the midline.

TABLE III: LD 50 FOR MIXED 250 KVP- AND 50-KVP RADIATION IN DOGS: COMPARISON OF VARIOUS DOSE ESTIMATES

Group	Treatment* (roentgens)		Estimated Tissue Dose		
			Surface (rads)	Midline (rads)	Megagr. (rads)
1	250 kvp...	275	224	206	2.25
	50 kvp...	0	0	0	0
		275	224	206	2.25
2	250 kvp...	226	184	169	1.85
	50 kvp...	1,000	485	34	0.73
		1,226	669	203	2.58
3	250 kvp...	205	167	153	1.68
	50 kvp...	3,000	1,455	101	2.20
		3,205	1,622	254	3.88

* Treatment is defined as the exposure air dose at the potential midline of the exposed animal.

In Table III are compiled several dose measures for comparative purposes. It is clear from these data that no significant conclusions can be drawn with respect to predicted biological effectiveness from either the air dose, surface dose, or integral dose. The midline tissue dose gives relatively good correlation between equieffective exposures of the mixed radiations at the 1,000 r added 50-kvp level. However, for 3,000 r added 50-kvp radiation a significant departure from the expected value is seen. The differences reflect the effect of bone attenuation on that portion of the lower-energy radiation that reaches critical regions. In any case, these differences are small, considering the magnitude of the applied surface dose, and are sensitive to the variability in animal size. Efforts are made during exposure to constrain the animals, physically, to the lateral dimension of the phantom, 16 cm., but some variation from the nominal diameter is unavoidable. The midline dose of 50-kvp radiation is sensitive to this variability. For example, a 16-cm. dog would have a midline tissue dose of 3.5 per cent of the air dose, while a 20-cm. dog would have a 2.3 per cent midline tissue dose. In terms of midline tissue dose, this represents an extreme of variation of only 6 per cent for 1,000 r added 50-kvp and 12 per cent for 3,000 r added 50-kvp radiation. The average error would be 2 per cent and 4 per cent, respectively, a small deviation compared to overall precision of the methods.

With this reservation, these observations are in general accord with those reported previously by Alpen, Jones, Hechter, and Bond (4), in which it was shown that the midline tissue dose failed to afford an accurate prediction of biological effectiveness of 100-kvp radiation because of the inherent shielding provided by bone. If the lethal midline tissue dose of 250-kvp radiation is 206 rads (Table III) as determined by exposure to the more penetrating radiation alone, then the difference between this value and the observed midline value of 254 rads for lethality with the added 3,000 r of 50-kvp radiation represents an increment of about 50 rads of midline tissue dose, which is ineffective in bone marrow destruction.

The other radiosensitive tissue in this system which must be considered in addition to bone marrow is the gastrointestinal tract. With 3,000 r of 50-kvp radiation, portions of the gastrointestinal tract are receiving as much as 1,400 rads, while no portion is receiving less than the midline contribution of 100 rads. To this must be added approximately 150 rads of 250-kvp radiation received by the whole gut. No significant gastrointestinal effects resulted from this exposure of the whole gut to doses ranging from 250 to 1,550 rads. One must conclude that intact function in the lesser irradiated portions were capable of reversing the effects which would result from irradiating the remainder at the higher dose level. This supports the observation of Swift and Taketa (7) that shielding of only a very small portion of the gut in the rat successfully prevents development of the gastrointestinal syndrome.

Another interesting consideration arising from the combined radiation exposure given these experimental animals is the relative importance of skin dose in affecting the lethal outcome of exposure to more penetrating ionizing radiation. Two groups of investigators (8, 9) have reported on the increased lethality of

ionizing radiation when the skin is concomitantly damaged by thermal injury. The studies reported here indicate that, at least in this range of skin doses, no significant reduction of the LD 50 ensues as the result of the surface irradiation. Certain aspects must be borne in mind, however. The two references cited list the contributing causes to increased lethality of irradiation accompanying skin burns as increased early fluid loss and infection. Neither of these effects is likely to be observed in studies such as those presently reported because of the surface dose experienced.

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SUMMARIO IN INTERLINGUA

Effectos Exercite per Concomitante Roentgeno-Radiation Superficial Super Le Letalitate De Radios Roentgen De 250 kvp

Si le efficacia letal de irradiation es reflectite le plus accuratemente in le dose absorbite in le medulla ossee, alora un radiation que non es capace a penetrar le protection del structuras ossee non pote producer un damno biologic que augmenta le letalitate acute. Iste hypothese esseva testate per le administration concomitante a canes de doses massive de radios Roentgen molle (50 kvp) con un irradiation de 250 kvp. Le DL_{50} del radios Roentgen de 250 kvp sol esseva determinate como 275 r. Un leve sed statisticamente significative reduction de iste cifra esseva observate in gruppos de canes etiam exponite a 1.000 r o 3.000 r de irradiation de 50 kvp.

Le histodosage centro-linear es discutite como mesura del efficacia biologic. A generalmente parlar, le presente studios supporta le previe observation que ille dosage non representa un base pro le accurate prediction del efficacia biologic de radiation de 100 kv, a causa del inherente protection fornite per le osso.

Altere observationes es facite con respecto al vias gastrointestinal e le importantia relative del dose al pelle como factor afficiente le effecto letal de exposition a un plus penetrante radiation ionisante.

Joint Changes in Swine Erysipelas[1]

PAUL T. MEYERS, M.D.

Erysipelothrix rhusiopathiae suis causes a septicemia in swine and, when it lodges in the joints, produces a characteristic radiographic change which is shown by the present study to be pathognomonic for this organism. In man infection occurs chiefly as an erysipeloid skin process. Workers handling raw meats or fish are chiefly infected. The skin involvement is a rather typical, raised, red, demarcated lesion on the hands or forearms and, in the more severe cases, on the torso as well. The bacillus occurs in other animals besides swine, and even fowl and birds are afflicted.

Fig. 1. Edematous joints in infected swine.

For this study the etiology was established by special definitive cultures performed by the Agricultural Research Service, U. S. Department of Agriculture, at its main laboratory in Beltsville, Maryland (1). Twenty-six joints from 25 animals were examined microscopically, and cultures were made with mouse and rabbit controls. This resulted in the recovery of the *Erysipelothrix rhusiopathiae suis* in 14 or 53.8 per cent of the joints examined. The joints were carefully selected by trained U. S. Department of Agriculture veterinarians on assigned duty with John Morrell & Co., Ottumwa, Iowa, January 1956. The Research Service report contained the observation that the pigs were all of slaughter sizes and ages. Sikes (2) was quoted as stating that *Erysipelothrix rhusiopathiae suis* organisms usually disappear within 226 days after exposure, and it was concluded that "it is reasonable to assume that they disappear from a fair percentage of infected articulations in 150 days or so." Finally, the report continues: "If this assumption is correct, it might be that several of the twelve from which our workers failed to isolate *Erysipelothrix rhusiopathiae* had been infected earlier." Indeed, the radiographic survey which is the basis of this article did show that in nearly 100 per cent of the joints selected by the trained veterinarian inspectors some degree or another of joint pathology did exist. Over 200 joints selected because of gross objective findings from an average kill of

[1] From the Gilfillan Clinic, Bloomfield, Iowa. Presented as an Exhibit at the Forty-third Annual Meeting of the Radiological Society of North America, Chicago, Ill., Nov. 17–22, 1957. Accepted for publication in May 1958.

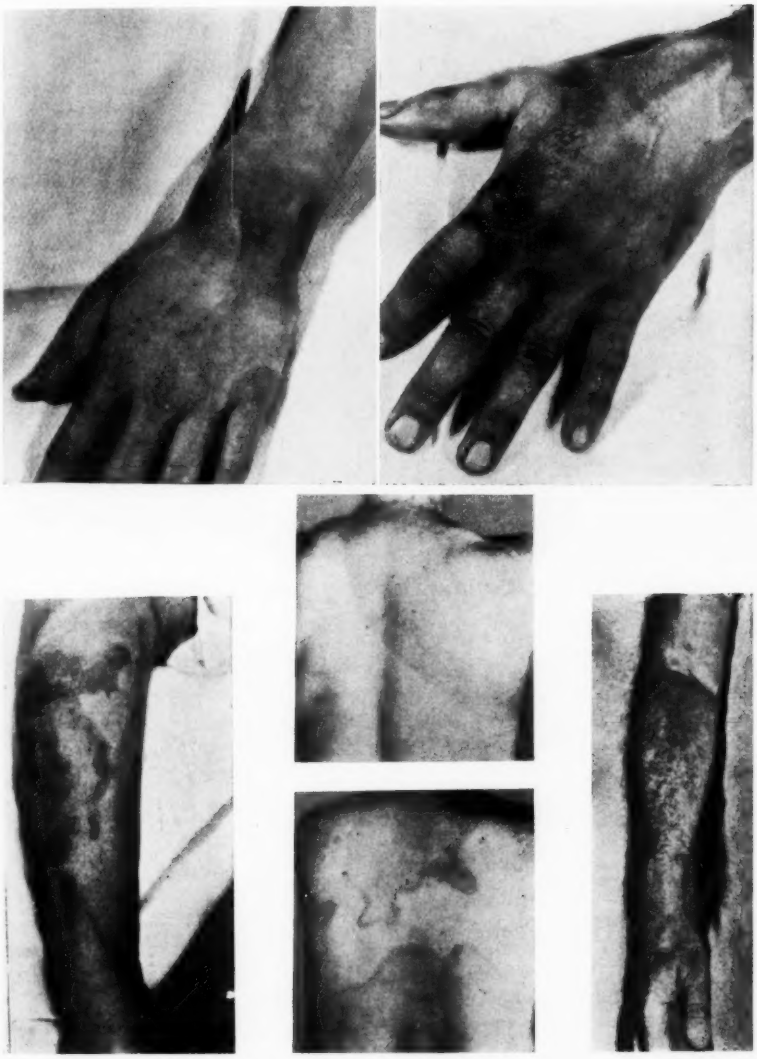


Fig. 2. Typical erysipeloid lesions of human skin.

5,000 swine per day, formed the basis for this x-ray study.

RADIOGRAPHIC FINDINGS

The most characteristic and notable feature in the radiographic studies of the joints of infected swine is a productive element. New bone is formed. Its site of predilection is the anterior or dorsal margin of the carpal and tarsal joints. This overgrowth of dense bone in the mild cases shows itself as small spurs or plateaus. In the late, advanced cases, there is a fusion of the anterior joint margins. In nearly every case there is a progressive invasion of the soft tissues anteriorly, until in the most aggravated cases an expansile process similar to a cauliflower growth is present. At no time is the "sunburst" appearance so characteristic of malignant bone tumors observed. The bony deposits and over-

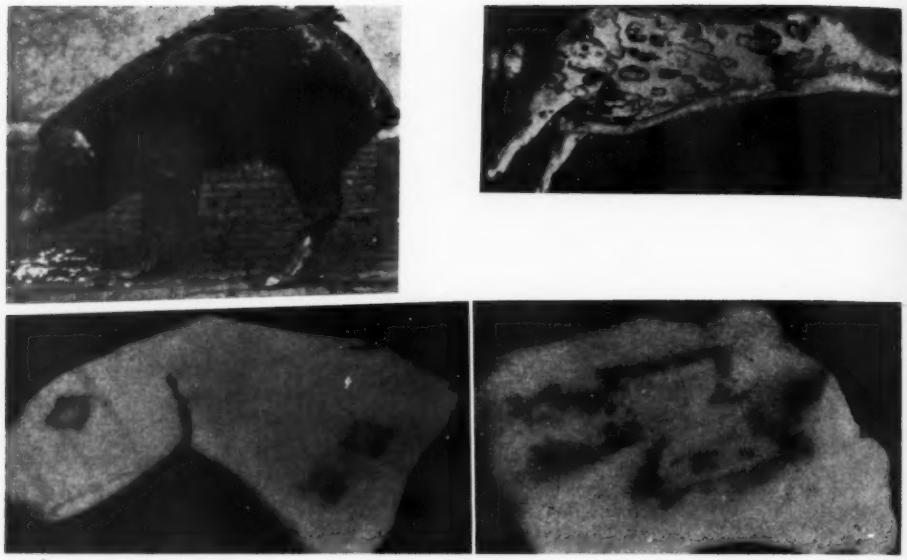


Fig. 3. Typical skin changes in swine, including "diamond spots."

Fig. 4. Erysipelothrix rhusiopathiae suis in pure culture.

Fig. 5. Typical changes in the carpal joints of swine.

growths are thus continuous with the dorsal margins of the carpal or tarsal bone sites as the case may be. More exactly, there is no "layering" or "onion peel" effect.

In the carpal and tarsal joints of these swine there is characteristic narrowing and, in the late phases, there is virtual obliteration of the normal anatomical outlines. Entering into this confluence of bone shadows is an obvious underdevelopment of the bones themselves. This at once indicates that the pathological process has been active in the joint since the early weeks of life, limiting and inhibiting the normal bone growth and development. Destruction of the cartilaginous surfaces is extensive.

The disease process frequently also involves the long bones adjacent to the carpal or tarsal joints, and in these there is a massive periostitis with new bone formation. Plaques of large, irregular, bony deposits are frequent on the anterior carpal or tarsal joint surfaces in juxtaposition thereto.

There is, in addition to the bony overgrowth into the soft tissues surrounding the joints, a considerable soft-tissue swelling and induration. This is the counterpart of the swollen joint which is obvious to the naked eye, and is the exact anatomical basis for the stiff joints which the alert farmer and professional handlers of these animals "on the hoof" identify with unerring accuracy.

To summarize, the radiographic changes are an infectious osteoarthritis and periostitis, with an unusually extensive periosteal proliferation and new bone production as the distinguishing features. Sequelae are bone underdevelopment, obliteration of the anatomical landmarks, periarticular edema, with bony ankylosis in the late, quiescent phase.

MICROSCOPIC FINDINGS

Examination of the microscopic sections (3, 4) from the leg joints of young hogs infected with *Erysipelothrix rhusiopathiae suis* reveals changes in the synovia, in the epiphyseal plate, and in the bone itself. In the periarticular tissues there is a proliferation of dense fibrous tissue. In the synovial tissues directly adjacent to the joint there are both plasma cells, lymphocytes, and neutrophils, lying subjacent to the mesothelial lining. As the

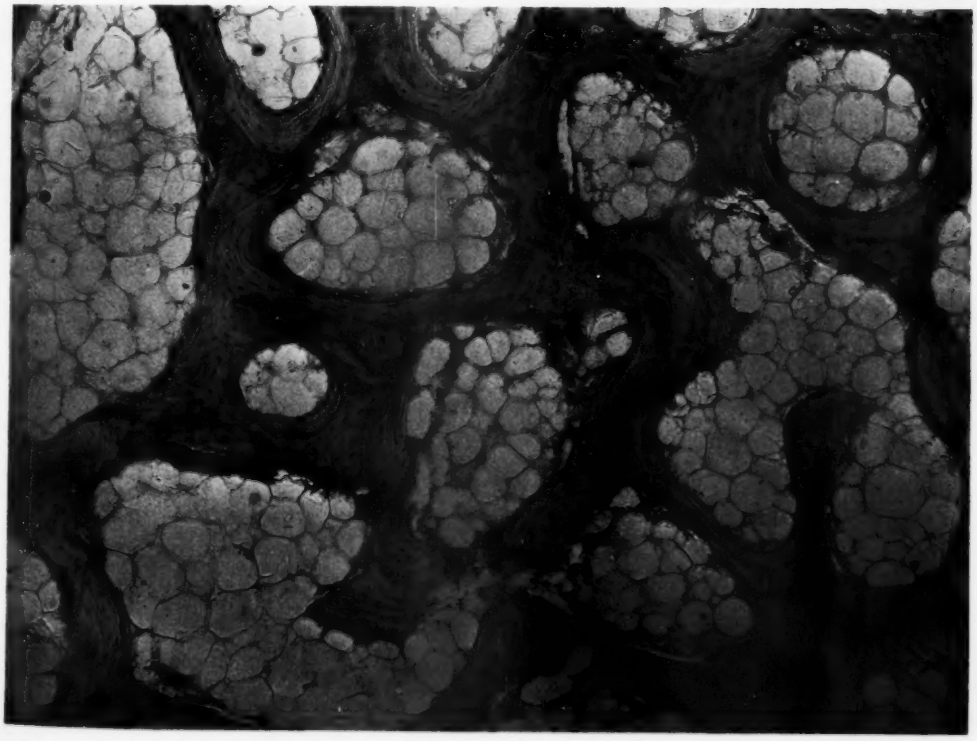
Fig. 6. Typical changes in the tarsal joints of swine.

disease progresses, there is migration of the synovia over the peripheral portions of the articular cartilage with resultant destruction of this cartilage, fibrosis of the joint, and irregular ossification of the periarticular tissues. Examination of the epiphyseal plate itself reveals a florid mixture of plasma cells, lymphocytes, and neutrophils, just under the cartilage. As a result, the cartilaginous columns which extend into the metaphysis undergo atrophy. Just below this on the diaphysis, the spicules of bone are found to be scanty and atrophic. Here, too, there is a diffuse infiltration of a mixed population of inflammatory cells. As one goes further down the diaphysis toward the center of the bone, inflammatory exudate disappears, but there are definite endarteritic changes in the small nutrient arteries.

The bone itself has a distinct pagetoid appearance, with irregular breccia. In the later stages of the disease, the inflammatory exudate disappears, but the resultant fibrosis and atrophy remain. Grossly, these changes are manifested in the early stages by a hemorrhagic epiphysitis and in the late stages by an atrophic and fibrotic joint. Sections of skin lesions reveal a purulent, ulcerative dermatitis with some endarteritic changes in the adjacent areas.

Fig. 7 (right). Joint showing chondritis and overlying fibrosis.

Fig. 8 (below). Bone showing a definite pagetoid appearance.



TREATMENT AND PREVENTION

The treatment of the skin lesions in man consists of the use of penicillin and sulfa drugs in the early acute stages, and in the injection of immune serum around the periphery of the lesions in the refractory cases. X-ray therapy is of no avail and, in fact, is contraindicated. The

Fig. 9. Skin lesion showing fibrosis of the underlying dermis, possibly with some vasodilatation.

preventive treatment and eradication of this disease in swine is simple. It consists of universal vaccination of newborn pigs (5). Despite the fact that swine erysipelas accounts for a loss, in the United States, of $24,000,000 per annum (6), the disease is not as well known, and not as well understood, as brucellosis or cholera. Brucellosis in swine accounts for an estimated loss of $10,000,000 and cholera $48,000,000 per annum. Inasmuch as the natural habitat of *Erysipelothrix rhusiopathiae suis* is the pig, the disease must be eradicated at its very source, in the breeding pens. Its spread to other farm animals and birds can never be stopped short of obligatory vaccinations of the young pigs.

SUMMARY

Swine erysipelas, caused by *Erysipelothrix rhusiopathiae suis*, is characterized by a septicemia and widespread parenchymal involvement. Identification of the organism in culture is difficult and expensive, and no blood or skin tests for its recognition have been perfected. The most rapid and least costly method of diagnosis is radiographic examination of the joints, which show typical changes, duplicated in no other condition. New bone formation, especially along the anterior and dorsal margins of the carpal and tarsal joints, is the outstanding feature, with progressive invasion of the soft tissues. The disease has its onset in early life and universal vaccination of newborn pigs is the sole preventive measure.

In man the disease is confined chiefly to handlers of raw pork and fish, giving rise to erysipeloid skin lesions which are usually amenable to treatment with penicillin and the sulfa drugs (7).

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SUMMARIO IN INTERLINGUA

Alterationes Articular In Erysipela Porcin

Erysipela porcin, causate per *Erysipelothrix rheusiopathiae suis*, es characterisate per un septicemia e extense affection parenchymal. Le identification del organismo in culturas es difficile e costose, e nulle test cutanee o hematologic pro su recognition ha essite perfectionate. Le plus rapide e le minus costose methodo diagnostic es le examine radiographic del articulationes, le quales monstra typic alterationes, non duplicate in ulle altere condition. Neoformation de osso, specialmente al longo del margines anterior e dorsal del articulationes carpal e tarsal, es le characteristica le plus distincte. Invasion del histos molle seque progressivemente. Le morbo se declara precocemente in le vita del porcos, e le vaccination universal de omne neonatos es le sol efficace mesura preventive.

In humanos le morbo es restringite principalmente a manipulatores de carne e de pisce crude. Illo produce erysipeloide lesiones cutanee que se presta usualmente al tractamento con penicillina e le drogas sulfa.

Unusual Gas-Forming Infections[1]

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GAS GANGRENE is generally caused by the clostridial bacteria. Certain anaerobic streptococci, the diphtheria bacillus, and *Actinomyces* may cause a gangrenous myositis resembling clostridial gas gangrene. Although gas infection is usually a disease of the battlefield, it may occur whenever necrotic tissue is present.

In World War I, Pettit reported the development of gas gangrene in 221 (5 per cent) of 4,377 patients, with a resulting fatality of 27.6 per cent. During the Korean War, among 4,900 battle casualties reported by Howard and Inui, only 4 cases of gas gangrene occurred, with no fatalities (2).

Clostridium welchii (*perfringens*) is the most important anaerobic organism in the formation of gas gangrene. The pathogenic powers of the clostridial bacilli result from production of one or more potent exotoxins. All *Clostridia* produce several different toxins, but usually only one of these is paramount in the genesis and progression of the disease. It is against this specific toxin that an appropriate antiserum is prepared. Certain of these toxins are enzymes and their specific substrates have been identified. This has been an important finding, leading toward the investigation of gas gangrene. These organisms will grow and produce their toxins only under conditions of markedly reduced oxygen tension. Generally, trauma, the presence of necrotic tissue, or a foreign body is sufficient to permit germination of the gas-forming bacteria. Once the toxins are produced, they diffuse into the surrounding tissues, causing necrosis and permitting spread of the organisms into new areas of reduced oxygen tension. *Clostridium welchii* has been studied extensively and it is clear that the alpha toxin is the element of prime importance. At surgery, changes in the infected muscles are noted, consisting of edema, loss of contractility, and discoloration which varies from a reddening to a dark purple mottling. On squeezing the tissues, bubbles of gas can be expressed.

Clostridia may exist as contaminants without producing any harmful effects. The stimulus for growth and production of the toxin is not well understood in spite of considerable study. Necrotic tissue is apparently the best catalyst for production of gas gangrene. The mere presence of *Clostridia* is of little significance, since they require delicately adjusted environmental conditions before they can produce the manifestations of disease. It must be strongly emphasized that clostridial infections in man are clinical and not bacteriologic entities. The spread of the disease is usually in the muscles and along the muscle planes, although other tissues may be involved.

One of the 2 cases to be reported here was due to *Clostridium welchii*, the other to an anaerobic streptococcus.

CASE REPORTS

CASE I: A 54-year-old white male with myeloid leukemia showed progression of the disease in spite of treatment with Chlorambucil, transfusions, and supportive measures. On the day prior to admission he experienced chills, fever, nausea, and a watery diarrhea. The following day he was better, although he complained of generalized aching. At 4:00 P.M. on that day he suffered severe pain in the abdomen, which radiated to the back, and pain in the left thigh. He was seen by his physician at 6:00 P.M., when he was found to have a temperature of 98°, pulse 110, and blood pressure 120/80. His abdomen was soft but he complained of pain in both lower quadrants and in the left leg. He was admitted to the hospital on Feb. 28, 1957, thirty hours after the onset of acute symptoms.

The temperature on admission was 94.4°, pulse 140, respirations 40, and blood pressure 120/80. The patient was acutely ill, with a reddish cyanosis about the face and extreme abdominal tenderness and rigidity over the right side. Three hours after

[1] Accepted for publication in May 1958.

admission the blood pressure was unobtainable and administration of Levophed was begun. The blood pressure then rose to 120/70. Supine and erect films showed free air in the abdomen, along the left psoas muscle and extending down into the left thigh (Fig. 1). A small amount of air was noted over the cecum.

Fig. 1. Case I. Erect abdominal film showing gas along the left psoas muscle, in the left lower abdominal wall, and over the left ischium.

The possibility of a ruptured viscus was considered, and exploratory laparotomy was performed. A moderate amount of free fluid was found in the abdomen. The retroperitoneal space was hemorrhagic and contained bubbles of air mixed with blood. There was a mass in the cecum which appeared to be neoplastic, but no perforation could be found. As the cecum was being examined the patient expired. Cardiac massage was instituted, but without success.

At necropsy, *Clostridium welchii* gas infection was found in the abdominal wall, the psoas muscles, the muscles of the left thigh, the terminal ileum, and the right colon. A leukemic mass involved the cecum, with perforation at the cecal tip. The genesis of the gas bacillus infection was explained by leukemic involvement of the mucous membrane and mesentery of the cecum, offering a focus of necrotic tissue.

CASE II: A 41-year-old white diabetic male was admitted on Aug. 13, 1957, because of a rectal abscess of one week duration. Two weeks prior to admission he had noticed bright red blood in the stools and defecation became increasingly painful. Examination disclosed a rectal abscess and a fistula.

Fig. 2. Case II. Soft-tissue film showing swelling of the scrotum, which contains a large amount of gas.

Surgical drainage was advised, but the patient refused. His diabetes, which was poorly controlled, was regulated and he was discharged fifteen days after admission.

Three days later he was readmitted. At this time his temperature was 105° and there was an extensive perirectal abscess with gangrene and necrosis of the perineum. Roentgenograms of the lower abdomen and scrotum showed soft-tissue swelling and a large amount of gas in the scrotum (Fig. 2). Without anesthesia the perineum was opened and a copious amount of gas and purulent material exuded. Vigorous treatment for gas gangrene was instituted, although no *Clostridia* could be identified. Anaerobic streptococci were found to be the cause of the gas infection. The patient did poorly and died twelve days later. Autopsy showed chronic congestive heart failure, bronchopneumonia, perineal abscess, and diabetes mellitus.

SUMMARY

Gas-producing infections are usually caused by the clostridial bacteria but other anaerobic organisms may produce the typical changes of gas gangrene. Two cases of gas infection are reported, one of which was caused by *Clostridium welchii* and the other by an anaerobic streptococcus. The presence of abnormal gas in any part of the body should suggest the possibility of gas infection.

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SUMMARIO IN INTERLINGUA

Inusual Infectiones A Formation De Gas

Infectiones a formation de gas es usualmente causate per le bacterios clostridial, sed altere organismos anaerobie pote producer le typic alterationes de gangrena a gas. Es reportate duo casos de infection con formation de gas. Le un, causate per *Clostridium welchii*, interessava le parieteabdominal, le musculos psoatic, le musculos del femore sinistre, le ileus terminal, e le colon dextere. In le altere, causate per un streptococco anaerobie, un grande quantitate de gas esseva presente in le scroto. Le presentia anormal de gas in non importa qual parte del corpore deberea facer pensar al possibilitate de un infection a formation de gas.

The "Normal" Lumbosacral Spine[1]

CAPT. NEIL E. CROW, USAF (MC), and CAPT. BYRON G. BROGDON, USAF (MC)

FILMS of the lumbosacral spine of 936 healthy young males were reviewed, utilizing the double-reading technic. The men were Air Force Academy or Air Cadet applicants between the ages of seventeen and twenty-seven. All were in good general health and denied any recent or remote symptoms relating to the lumbosacral spine. Hence, they represent a large series of "healthy" young males with "normal" lumbosacral spines.

Anteroposterior and lateral views were obtained, usually in the erect position. Repeat or additional studies were made when indicated. All apparent normal variations, anomalies, and abnormalities were tabulated (Table I). There were also found isolated cases of calcified splenic capsule, possible giant-cell tumor, and old Legg-Perthes disease, but not in sufficient number to warrant tabulation.

It is felt that the findings reported in Table I provide a valuable statistical study for reference, teaching, and forensic purposes.

TABLE I: THE "NORMAL" LUMBOSACRAL SPINE (936 Cases)

Entity	Number	Per cent
Spina bifida occulta	334 total	35.7
Multiple	40	4.3
Previous Scheuermann's disease	194 total	20.7
With Schmorl's nodes	96	10.3
Scoliosis greater than 1 inch	5 total	0.5
Rudimentary ribs or ununited transverse processes	60 total	6.4
Transitional vetebrae	108 total	11.5
Sacralization	31	3.3
Bilateral	20	2.1
Unilateral	11	1.2
Lumbarization	77	8.2
Bilateral	56	6.0
Unilateral	21	2.2
Spondylolysis	71 total	7.6
Bilateral	57	6.1
Unilateral	14	1.5
Spondylolisthesis	42 total	4.5
Limbus vertebrae	9	1.0
Hemangioma	4	0.4
None of above variations	376	40.2

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SUMMARIO IN INTERLINGUA

Le "Normal" Spina Lumbosacral

Esseva facite roentgenogrammas del spina lumbosacral in 936 normal juvene masculos adulte, de inter dece-septe e vinti-septe annos de etate, sin gravamines —passate o presente—attribuibile a ille area. Omne apparentemente normal variationes e omne anomalias e anormalitates esseva tabulate. Esseva trovate evidentia de occulte spina bifide in 35,7 pro cento del serie, de previe morbo de Scheuermann in 20,7 pro cento, e de vertebras transitional in 11,5 pro cento. Altere conditiones que esseva observate minus frequentemente includeva scoliosis, costas rudimentari o processos transverse, spondylolyse, spondylolisthese, e hemangioma. Nulle de iste variationes esseva trovate in 40, 2 pro cento del subjectos.

[1] From the Radiology Service, 2349th USAF Hospital, Parks AFB, Calif. Accepted for publication in May 1958.

WORK IN PROGRESS*

Gonadal Dose in Radiation Therapy[1]

NORMAN A. BAILY, VIRGIL E. YODER, and MIGUEL A. BOZZINI

The use of x-rays in radiation therapy, particularly when benign conditions are treated, has created an interest in the gonadal dose delivered during such procedures. The study to be described here was initiated to investigate the gonadal dose as a function of x-ray energy, field size on the skin, and patient size, for various irradiated sites. The initial phases of this investigation have been carried out mainly in male patients. The study will be extended to include females and children.

GONADAL DOSE DUE TO X-RAY THERAPY

Beam Quality (h.v.l. in mm.)	Region of Applied Field	Skin Area Irradiated (cm.²)	Gonadal Dose (mr./100 r on skin)
1.3 Al	Head	1.5	0.17
1.3 Al	Head	3.5	0.10
1.3 Al	Head	4.0	0.15
1.3 Al	Head	4.5	1.0
1.3 Al	Head	5.5	0.10
1.3 Al	Head	6.0	0.15
0.45 Cu	Head	7.0	0.15
0.45 Cu	Head	12.5	0.50
0.45 Cu	Head	17	0.53
5.0 Cu	Head	80	5.0
5.0 Cu	Neck	48	3.2
5.0 Cu	Neck	120	4.4
5.0 Cu	Neck	150	56
0.45 Cu	Shoulder	11.5	10
1.0 Cu	Shoulder	200	91
5.0 Cu	Shoulder	225	31

The exposure dose was recorded with Victoreen 10-mr stray radiation chambers and Baldwin-Farmer type B.D. — 2/15 ionization chambers. For males, the chambers were taped to the scrotum, while in females the chambers were inserted in the vagina against the face of the cervix. Difficulties encountered were the very great energy dependence and directional dependence of some of the ionization chambers used. Chambers will be developed to extend the range of the present measurements to lower qualities common in dermatological practice. All chambers were calibrated against a secondary standard previously calibrated by the National Bureau of Standards.

The results to be presented at this time include irradiations to the head, neck, and shoulder areas for malignant lesions. These radiation fields are analogous to those used in dermatological practice, bursitis, chronic tonsillitis, keloids, inflammatory thyroid disease, etc. (1). Other areas will be investigated in future work. All dosages given are those recorded during actual treatments and with the use of coned fields. Observations on 34 cases are summarized in the accompanying table.

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Retention of Sr^{90} and Ca^{45} in Rhesus Monkeys[1]

PATRICIA W. DURBIN, MARILYN H. WILLIAMS, MARSHALL W. PARROTT, and HARDIN B. JONES

A four-term exponential equation has been published for the excretion of Sr^{90} by a group of 5 adolescent and 3 mature rhesus monkeys (1). The emergence on about the 300th day of a single component of long half-time (700 to 1,000 days) agrees with the results of Ward (2) for other species of monkeys and is at variance with the findings of Mays *et al* (3) for Sr^{90} in beagle dogs and of Norris *et al.* (4) for Ra^{226} in man.

Inclusion of new individuals in the experiment allows us to consider two distinct age groups, adolescent and mature animals. It seemed appropriate at this time to report some additional information for Sr^{90} and the preliminary results for Ca^{45} excretion by these same animals.

In all, the experiment now comprises 12 individuals: 9 adolescents, twenty-nine to thirty-eight months old, and 3 adults that were more than fifty months old when injected. Each animal received 35 μc of Sr^{90} (8 to 12 μc/kilo) in a single intravenous injection. The 6 most recently injected younger monkeys also received 135 μc Ca^{45}. Excretion rates of the adults have been followed for twenty-three to fifty-six months, and of the adolescents for two to twenty-three months. Retention was measured directly in 1 adolescent sacrificed at three months.

Beta activities of Sr^{90}-Y^{90} and Ca^{45} are measured in suitable aliquots of ashed monkey excreta by differential filtration. Appropriate corrections are applied for self-absorption and the K^{40} content of monkey excreta.

The retention curve (derived from the excretion rate curve) that best fits the data for the adolescent monkeys is

* The papers presented here were submitted for publication in October 1958 and were read at the Forty-fourth Annual Meeting of the Radiological Society of North America (Section C), Nov. 19, 1958.

$$R^{3}_{Sr} = 28.6\%e^{-1.36t} + 17.2\%e^{-0.13t} + 12.6\%e^{-0.012t} + 41.6\%e^{-6.42 \times 10^{-4}t}.$$

Retention calculated from this curve, 42.9 per cent, agrees well with the measured retention of the sacrificed adolescent, 43.2 per cent. The slope constants of this curve are essentially the same as those of the curve previously published for the mixed-age group. Although the coefficients differ, these differences can be ascribed to the greater Sr^{90} elimination by the adult animals immediately after injection and retention of less Sr^{90} in the long-term turnover compartment. The adult group is too small to allow precise determination of the coefficients; however, they resemble those reported for the mixed group.

During the first seventy days, when the Sr^{90} excretion rate is declining rapidly, the data for the younger animals can be fitted to a power function, $E(\%/d) = 11\%T^{-1.12}$. After the seventieth day the excretion rate deviates markedly from the above power function, but it is too early to tell whether this deviation is a second power function of more positive slope or a region of curvature as indicated by Ward (2).

The Ca^{45} excretion rate cannot be fitted to a power function during any appreciable interval; however, these data can be roughly described by a series of exponentials. The preliminary results suggest that the turnover rates of the rapid turnover compartments will differ from those determined for Sr^{90} in the same monkeys.

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Treatment Planning with Electrons of 20–35 MEV for Deep-Seated Tumors[1]

J. OVADIA, J. DUPLEX, and D. McISAAC

The high-energy electron facility at Michael Reese Hospital, consisting of a linear accelerator (essentially a copy of the Mark II linear accelerator at Stanford University), and a magnet system which analyzes the energy of the electrons emerging from the accelerator and deflects them into the patient treatment area, has been previously described (1). It has been modified to insure more reliable and simplified operation; in particular, a lead-scattering foil (0.016 inch thick) at the exit of the magnet system is used to provide a uniform field up to 18 cm. diameter for all energies up to 35 MEV at the treatment area, which is located at a distance of 1.3 meters. Various field sizes are obtained by absorbing part of this beam in various collimators made of 1-inch aluminum backed by 1/2-inch brass.

Dose distributions were obtained by exposing Kodak Industrial AA film in a Presdwood phantom (density 1.01) and measuring film density with a Macbeth-Ansco densitometer. A modified drafting machine in conjunction with the densitometer proved very useful in directly plotting isodose curves.

With reduction of the dose rate of the electron beam to the order of 1 rad/min. in tissue-equivalent material, the films are irradiated for approximately two minutes to obtain a density of the order of 2.0. Any effects arising from fluctuations in the electron beam as it is first turned on are thus minimized, and an average of the distribution is obtained for times comparable to those used for therapy.

The relative dose delivered to every film was determined to 1 per cent by use of a transmission ionization chamber and current integrator (modified Victoreen Radocon meter). The net density of industrial AA film (up to a density of 2.4) was found to be directly proportional to the dose for the electron energies used.

In setting up treatment plans for deep-seated tumors it was found that optimum distributions in the tumor area are obtained by use of only one field, or two fields from opposite directions for centrally located tumors. The ratio of tumor dose to integral dose is a maximum when one or at most two fields are used in this manner. Such treatment plans are employed for tumors of the esophagus, bladder, lung, and for tumors in the head and neck area.

Recently, the possibility of using grid therapy with electrons in the energy range of 15 to 35 MEV was investigated. This method, first suggested for high energy electrons by Becker (2), presents a possible method of sparing healthy tissues overlying the tumor. The scattering characteristics of electrons in the energy range of 15 to 35 MEV are such that they lend themselves particularly well to grid therapy, sparing not only the skin but also the adjacent underlying tissue for a considerable and controllable depth. Little scattering occurs for the first one-third of the electron range, so that superficial tissue is irradiated nonuniformly by sharp, well defined columns of radiation. At greater depths, and presumably at the location of deep-seated tumors, the irradiation is completely uniform.

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A Tumour Dose Rate Calculator[1]

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Tumour dose rate in rotation therapy is the product of exposure dose rate in air at the centre of rotation multiplied by the tumour-air ratio (1, 2). The device shown in Figure 1 consists of a family of curves, on full logarithmic paper, of the tumour-air ratios plotted against field area, with thickness of overlying tissue as parameter. The exposure dose rate at the centre of rotation, plotted against the same abscissa but with reversed ordinate scale, is shown at A on Figure 1. A cursor carrying a logarithmic scale B can slide across the family of tumour-air ratio curves in such a way that a reference point on it always stays on the exposure dose rate graph A. The ordinate scales of A and B, and of the tumour-air ratio curves have the same length of logarithmic cycle and correspond to the CI, C, and D scales of a slide rule. Hence one can ensure that any value read on scale B corresponding to a value on the tumour-air ratio plot will be the product of that tumour-air ratio and the exposure dose rate. The tumour dose rate is thus read on scale B, at the proper field area, at its intersection with the tumour-air ratio curve for the required thickness of overlying tissue.

The calculator has been constructed for use with the AECL Cobalt-60 Theratron Junior Unit (4) and incorporates a compensating movement of scale B to allow for radioactive source decay (3). A series of notches cut in scale B at intervals corresponding to eight weeks decay can be aligned in turn with a lock nut, ensuring that the dose rate shown on the calculator will never differ by more than 1 per cent from the true dose rate. When used with an x-ray unit, adjustments could be made in a similar way to allow for any changes in tube output.

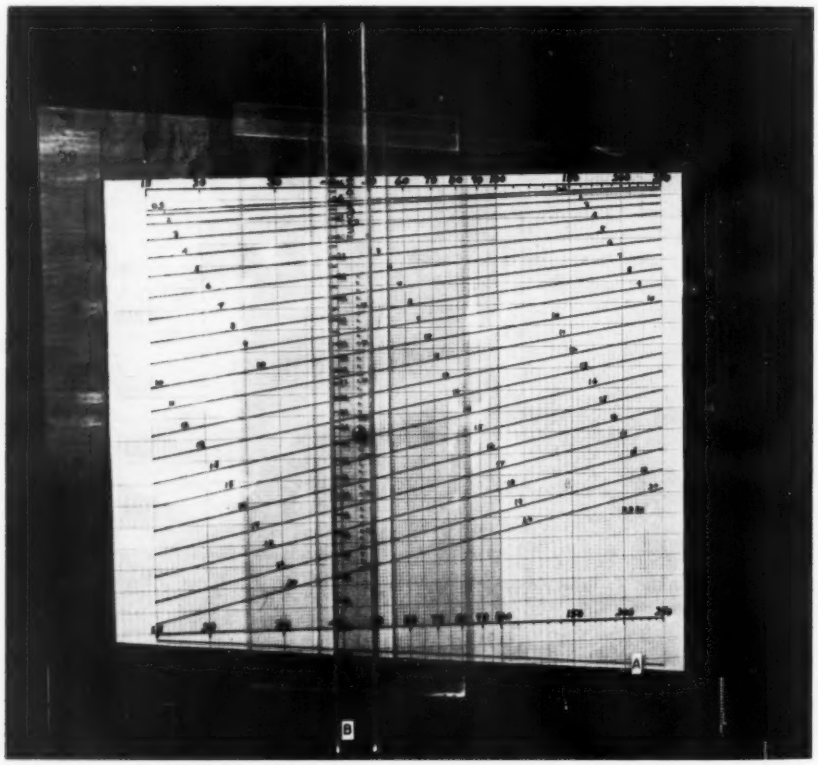

Figure 1.

It will be noted that the curves for the tumour-air ratios and exposure dose rate plotted against area on full logarithmic paper are straight lines. This experimental fact, greatly simplifying construc-

tion of the calculator, was found to be accurate to better than 1 per cent. For other therapy units, the exposure dose rate may not obey this simple relation and it would then be necessary to link scale B to curve A mechanically. Any errors introduced by disregarding the effect of field elongation on tumour-air ratios and on exposure dose rate are, at worst, 2 to 3 per cent, and, if necessary, may be allowed for in separate correction tables.

While the calculator is designed for use with a rotating cobalt unit, its use is by no means restricted to rotation therapy, and it is, in fact, used by us in all fixed-field as well as rotation treatments. Obviously tumour-air ratios can be used whenever the tumour centre is kept at a fixed distance from the radiation source. In conventional fixed-field therapy, the tumour dose rate is the product of surface dose rate and central axis per cent depth dose. A calculator can be designed on exactly similar principles for these conditions.

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[1] From the Physics Department, The Ontario Cancer Foundation London Clinic, London, Ontario (Ivan H. Smith, M.D., Director).

Field Shaping and Selective Protection in Megavolt Radiation Therapy

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The availability of intense sources of megavolt radiation makes possible the treatment of regional as well as localized disease with more adequate doses. These new capabilities are often best exploited by the use of large treatment fields, carefully shaped to include known tumor and local extensions and to exclude uninvolved regions. This procedure results in a more uniform dose distribution and reduces the problems of overlap inherent in the multiple field approach.

Field shaping, or field outline control, is accomplished by interposing sufficient thickness of absorbing material into the beam cross section. In addition, the beam may be intensity-modulated by filters to adjust for variations in the anatomical thickness. In our megavolt x-ray equipment a light-beam localizer is used to facilitate the placing of such absorbers and filters. Double-exposure radiographs are taken to confirm and record the field location and the position of these absorbers. Fields of typical shape used in both rotational and opposing portal therapy that have evolved from a nine-year clinical investigation program will be presented.

In rotational therapy it is often desirable to reduce or to minimize the dose to certain radiation-sensitive regions within the field. Several methods have been developed to accomplish such selective shielding consistent with the treatment of adjacent involved regions. Technics will be described for shielding the spinal cord and the eye during rotational therapy of surrounding and adjacent tissue.

The method for providing spinal cord protection makes use of a shaped absorber rod rotating in synchronism with the patient. This rod is positioned between the target and patient and bent so that its projected size and shape cover the spinal cord in both lateral and anteroposterior projections. As the patient and absorber rod are synchronously rotated, the radiation to the cord is continuously attenuated. The degree of such selective protection depends, among other things, on the thickness and density of the absorber. By the use of high density materials such as gold, the dose of 2 MEV radiation delivered by the direct beam to the axis of the cord is reduced to half by rods of 3/8-inch diameter. To obtain equivalent attenuation with lead rods, greater thicknesses must be used. The gradient in dose around the protected region and several other factors must be taken into account in planning the treatment.

Protection of the eyes can be accomplished during rotational therapy treatment by a similar method. Two horizontal parallel absorber rods directed to cover the eyes are used. These rods are of sufficient length to reduce to about 1 per cent the direct beam transmitted through them and are kept parallel as they are rotated about an appropriate axis synchronously with the patient. Throughout the rotation each absorber rod thus remains in continuous alignment with its target eye. With this procedure it is necessary to use attenuation filters to make the dosage more uniform above and below the eyes.

The dose received by the selectively protected region within a field is dependent on the transmission of the absorber and on the scattered radiation from the treatment field. Even when the direct beam is virtually eliminated, the scattered radiation may still deliver an appreciable dose to the shielded region.

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Analysis of the Cardio-Portal Circulation Time Curve, Determined by External Scintillation Detection[1]

ISMAEL MENA[2] and LESLIE R. BENNETT, M.D.

The exploration of the hemodynamics of the liver is of interest to the physiologist and to the clinician who has to care for patients with portal hypertension. The object of this paper is to report a technic that gives useful information regarding this problem. It utilizes externally placed scintillation detectors and intravenous injection of radioactive serum albumin.

One of the scintillation probes is placed over the heart, feeding the information to an EPUT meter (events per unit time); the other is placed over the liver and connected to a ratemeter-recorder unit. In a fasting individual 0.25 μc/kg. of radioiodinated serum albumin (RISA) is injected rapidly to an antecubital vein. Recording over the heart and liver is begun at the moment of RISA injection and is concluded when a well defined plateau is reached over the liver. Both the cardiac and liver data are plotted on the same graph, with time the abscissa and activity the ordinate. The cardiac curve is a useful reference point from which determinations of forward circulation times can be made. A clear-cut curve is a good proof that no technical errors were introduced by an unsatisfactory injection. It gives information also regarding the presence of cardiopulmonary disease, which can disrupt the liver hemodynamic. The curve builds up normally 10 to 12 seconds after injection and is followed by an exponential drop. Simultaneously after the heart peak, increasing radioactivity is detected over the liver, building up to a peak in 25 seconds, standard deviation 3.04 seconds.

This determination was performed in 40 normal individuals. The circulation time between the heart peak and the liver peak is defined as the cardio-portal circulation time. This curve represents a composite of the radioactivity reaching the liver *via* the hepatic artery, followed by the amount of tracer arriving *via* the portal vein. Neither segment is clearly individualized in the normal tracing.

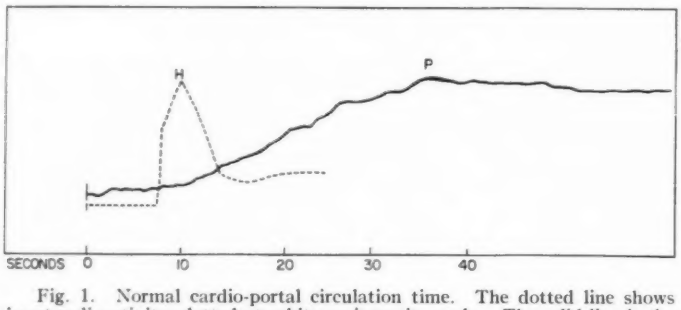

Fig. 1. Normal cardio-portal circulation time. The dotted line shows heart radioactivity plotted at arbitrary intensity scale. The solid line is the original record of radioactivity over the liver. Time constant = seconds.

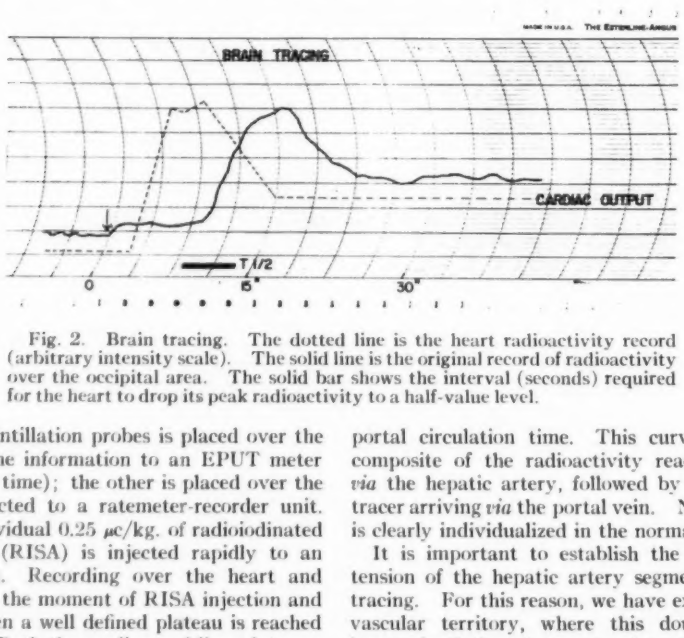

Fig. 2. Brain tracing. The dotted line is the heart radioactivity record (arbitrary intensity scale). The solid line is the original record of radioactivity over the occipital area. The solid bar shows the interval (seconds) required for the heart to drop its peak radioactivity to a half-value level.

It is important to establish the shape and extension of the hepatic artery segment of the liver tracing. For this reason, we have explored another vascular territory, where this double successive input circulation does not exist. With the same device, the recording of the passage of the radioactive bolus through the heart and afterwards through the brain gives the circulatory pattern

shown in Figure 2. The brain tracing, in the occipital area, starts to build up immediately after heart peak, reaching its maximum altitude in 10 to 12 seconds. In 8 individuals 80 per cent of the ultimate height is reached at the moment the heart exponential drop is at the half value of its peak level.

Other Data from Dog Experiments: Injection of the mesenteric artery, after clamping the hepatic artery or the portal vein, has confirmed this observation. At the moment when the heart radioactivity level has dropped to a value half of the peak (6 to 8 seconds), 80 per cent of the hepatic artery activity has already built up in the liver. At this early time there is no significant appearance of radioactivity arriving *via* the portal vein. In normal individuals this criterion shows the hepatic artery activity to be 30 to 40 per cent of the ultimate liver activity, and independent of the cardiac output variations. Changes have been shown in hepatitis, portacaval shunts, and after administration of several drugs.

Some other pathological conditions are associated with other changes in the cardio-portal circulation time. In 30 cirrhotic patients the circulation time was delayed to 46 seconds, standard deviation 6.6 seconds.

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[2] Fellow of the Henry L. and Grace Doherty Charitable Foundation, Inc., New York, N. Y.

A Three Electrode Condenser Ionization Chamber with High Sensitivity and Wide Dose Range[1]

JAN CEDERLUND[2]

In a conventional condenser-ionization chamber, dose is measured as the difference of two voltages. The accuracy for low doses is limited by two effects. In the first place, such doses are measured as the difference between two large and almost equal voltages. Furthermore, leakage across the insulator must be taken into account. In addition, large doses cannot be measured since they will discharge the chamber completely. This is a serious drawback if one has only a single opportunity to measure a dose of unknown magnitude, as is often the case in protection work.

The dose range can be extended downward by introducing a guard ring and connecting a battery between this and the chamber walls. When starting a measurement, the central electrode has the same potential as the guard ring, thus reducing leakage for small doses. Also, one can now use a more sensitive electrometer to detect a voltage increase on the central electrode that is small compared with the collecting voltage (Spiers 1).

Since, however, the battery has to deliver an extremely small current, it can be replaced by a condenser. In order to conserve space, this condenser may be incorporated as a structural part of the chamber. This is essentially what has been done in the device described here. In addition, the range has been extended upward by constructing the chamber as a double chamber with a large air volume for the low dose range and a small air volume for the high dose range in somewhat the manner described by Sievert and Walstam (2).

The special chamber was constructed from a Type BD11 protection chamber (3). The charging end, the amber insulator of the chamber, and the central electrode were left unaltered, but the large air-wall cap was replaced with a Teflon cap of the same size which was coated on the inside and outside with a layer of Aquadag. The layer on the outside, surface A, was insulated from the layer on the inside, surface B. The inside surface can be charged through a small hole in the end of this cap. The chamber now has three separate electrodes, surfaces A and B already described, and the conducting central electrode, C.

The chamber has two air volumes, a large one between electrodes B and C (the normal region of charge collection in the BD11 chamber) and a small one between A and C (in what is normally the charging end of the BDll chamber).

To charge this chamber, the outer surface A and the central electrode C are connected together and to ground, and a potential of about 300 volts is placed on electrode B.

When the chamber is placed in radiation, ions are first collected in the large volume, which raises the potential of the central electrode C with respect to A, the outer electrode. For a dose of about 300 mr, electrodes B and C come to essentially the same potential because of the ionization current in the large air volume. On further irradiation, the electrodes B and C will remain at the same potential with respect to each other and the charge stored by the condenser formed by B and A will be discharged through the small air volume to electrode A. With this arrangement, a dose of about 300 mr may be measured using the large air volume, and doses from 300 mr to 5,000 mr subsequently measured with the small air volume.

After the irradiation has taken place, the chamber is measured in the following way. The potential between the inner surface B and outer surface A is measured. If this is small, the dose which has been delivered is in the range 0–300 mr so that the operator removes the normal charging cap of the chamber and measures the potential difference between the central electrode C and the outer electrode A. The gain in potential of C from ground potential is a measure of the dose delivered. It should be noted that this offers a real advantage, for the two electrodes were originally at the same potential, so that the small change in potential is measured with reference to 0 potential. On the other hand, if the original measurement showed that B had changed

in potential with respect to A by a large amount, then this measurement alone would determine the dose, which would now be in the 300 to 5,000 mr range.

The device appears to be a practical protection chamber allowing for accurate measurement of small doses but, at the same time, capable of measuring large doses.

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[1] From the Ontario Cancer Institute, Toronto, Ont., Canada.
[2] On leave from Radiofysiska Institutionen, Lund, Sweden.

Measurement of Integral Dose in Unit Density Phantoms of Uniform Cross Section[1]

H. H. ROSSI, R. LEIBOWITZ, and F. de FRIESS

The concept of integral dose has useful applications in radiologic practice. In therapy the ratio of tumor dose to integral dose may be considered as an index of treatment efficacy and, in efforts to reduce patient dosage in diagnostic procedures, integral dose can serve as a practical numerical measure of unwanted exposure. Since the dose distribution is usually variable, both parallel and perpendicular to the axis of an externally applied radiation beam, even approximate computational or experimental determinations of integral dose have been found difficult. The method described here appears to be a simple and practical solution in the case of long uniform cylinders in the approximate shape of the human trunk.

Since most of the scattering of x-radiation by a patient is due to unit-density tissues, and since density variations in the body interior have little effect on integral dose, the employment of homogeneous cylinders of unit density would appear to be acceptable.

The principle of the method is to sample the dose at each point in the irradiated phantom (Fig. 1). This is accomplished by the employment of an ionization chamber having a very narrow spacing but extending over a complete section of the phantom. To prevent unobstructed passage for the beam and in order to obtain a circular cross section, the phantom is cut at its center in a plane which is at 45 degrees with its axis. Relative motion of x-ray tube and phantom results in a uniform sampling along the

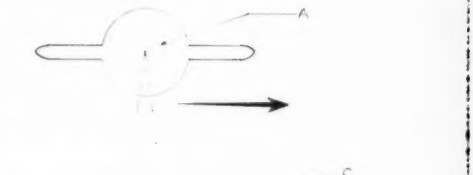

Fig. 1. Schematic representation of method. A. X-ray tube. B. Phantom. C. Sensitive volume of chamber.

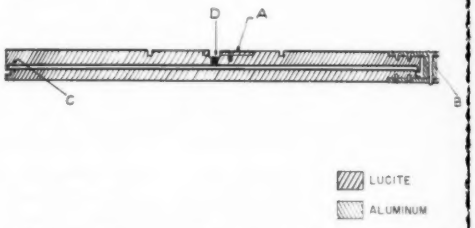

Fig. 2. Cross section of chamber. A. Rotating protective shield for contact (shown in open position). B. One of three spacers. C. Annular groove surrounding collecting electrode. D. Conducting plastic contact to collecting electrode. Heavy lines indicate surfaces covered by colloidal graphite.

axis of the phantom. If the relative excursion of the tube and phantom is sufficiently large and symmetric about the chamber center, all significant contributions to the integral dose are equally sampled. With an electrometer reading of R divisions, a chamber sensitivity of C divisions/rad, a phantom cross-sectional area A and a relative velocity V, it can be shown that the integral dose rate is given by

$$\text{ID} = \frac{RA}{CV} \text{ gm. rads/sec.}$$

The phantom is constructed of unit density Presdwood. It is a 4-foot cylinder of elliptical cross section, the major and minor axes being 12 and 8 inches, respectively. The ionization chamber (Fig. 2) is a circular parallel plate capacitor 12 inches in diameter, made of Lucite. Spacers permit a variable plate separation of the order of 1 mm. One plate is entirely covered with Aquadag, the other plate is similarly covered, but an annular groove results in two mutually insulated conducting surfaces, one of which may be charged by means of the conducting plastic plug provided. An eccentric plastic shield serves to protect the insulation surrounding this plug when it is disconnected from the electrometer. The two plates are fastened to each other

by means of three aluminum spacers which also serve to interconnect the grounded surfaces. The chamber is charged by placing it on a special adapter, which establishes connection to a Victoreen Minometer. Motion of the x-ray tube is provided by a synchronous motor. A series of microswitches control the degree of excursion and the period of radiation emission by the x-ray tube.

Since the sensitive volume of the chamber is surrounded by light-weight plastic only, C is substantially independent of x-ray energy. Calibration is performed by delivery of known exposure doses with appropriate corrections for absorption by the front plate and back-scatter by the back plate.

Initial studies have yielded consistent results, and it is believed that the simplicity of this method makes it possible to investigate a large variety of exposure conditions. Detailed results will be reported at a future date.

[1] From the Presbyterian Hospital, New York, N. Y.

A Method for Testing Radium Containers for Leakage Using the Well-Type Scintillation Counter[1]

JOHN HALE, Ph.D.

A new method for testing for leakage of radon from clinical radium containers has been developed. Preliminary tests show the method to be reproducible and highly sensitive. It is based on trapping the radon which escapes from faulty radium containers in a mixture of water and activated charcoal and subsequently measuring the radon in a well-type scintillation counter.

Method: Mix 5 ml. of tap water with 0.37 gm. (1 level 1/4 teaspoonful) of activated charcoal in a test tube suitable for well-type scintillation counter use. Place the radium container to be tested in the test tube. Stopper test tube. Leave radium in place for twenty-four hours. Remove radium. Replace stopper. Wait twenty-four hours and count in a well-type scintillation counter.

Theory: If it is assumed that radon leaks from a faulty radium container at a constant rate, the rate of leakage, Rn, is related to the count rate, C, by:

$$Rn = \frac{\lambda CKe^{\lambda T}}{(1-f)(1-e^{-\lambda t})}\ \mu c/\text{min},$$

where K (μc/count per min.) is the counter calibration factor; t is the time the radium container was left in the test tube; T is the time interval between removal of radium and counting; λ is the radon decay constant; and f is the fraction of radon lost when the radium is removed from the test tube.

Experimental: To establish the values of the constants involved in the equation, preliminary tests were made on 5–0.5-mg. radium cells previously known to be leaking. The half-life of the radioactivity within the test tube was observed to be 3.9 ± 0.1 days, confirming that the radioisotope was radon in equilibrium with its decay products. Leakage through the stopper was less than 1 per cent per day. Additional tests showed that f was less than 1/50. Repetitive tests on the same radium containers showed that the method was reproducible to about ±7 per cent. The counting sensitivity for a conventional well-type scintillation counter was found to be 1.2×10^6 counts per minute per μg. by comparison with radium standards. Under the conditions given above, and for a standard error of 50 per cent of net count rate with a one-minute sample count and a ten-minute background count, the minimum detectable leak was 2.5×10^{-8} mc for the twenty-four hours of the test. This corresponds to 1.4×10^{-7} mg. of completely de-emanated radium.

Conclusions: The method appears to have the following advantages:

1. With proper planning of operations, a large number of radium containers can be tested easily.
2. Handling procedures are simple, so that exposure to the operator is minimal.
3. The method is quantitative.
4. The method is quite sensitive, ample to detect significant radon leakage from clinical sources.
5. Previous methods used for testing clinical radium containers have been based on the measurement of alpha particles from Ra A-B-C (effective half-life about twenty minutes), so that counting had to be done immediately. The measurement of radon, to the contrary, allows counting to be done several days after testing. This makes it possible to use a central counting facility for radiation safety survey work, since the radium can be tested in its normal storage place and only the test tubes transported to the counting facility.

[1] From the Department of Radiology, Hospital of the University of Pennsylvania and the Wm. H. Donner Center for Radiology, University of Pennsylvania, Philadelphia 4, Penna. This work was supported in part by a grant (C-1984) from the National Cancer Institute, U. S. Public Health Service.

Characteristics of a Photocell (CdS) and Scintillation Phosphor (NaI) Radiation Detection System[1]

THEODORE FIELDS, GLENN CLAYTON, and JOSEPH KENSKI

Recent investigations of the single-crystal type of CdS detector for radiation measurements have indicated undesirable characteristics such as temperature dependency and nonreproducibility from crystal to crystal. A layer-type CdS cell, developed by the Hupp Electronics Company, was found more effective. This cell is made from CdS powder combined with small amounts of copper and zinc and

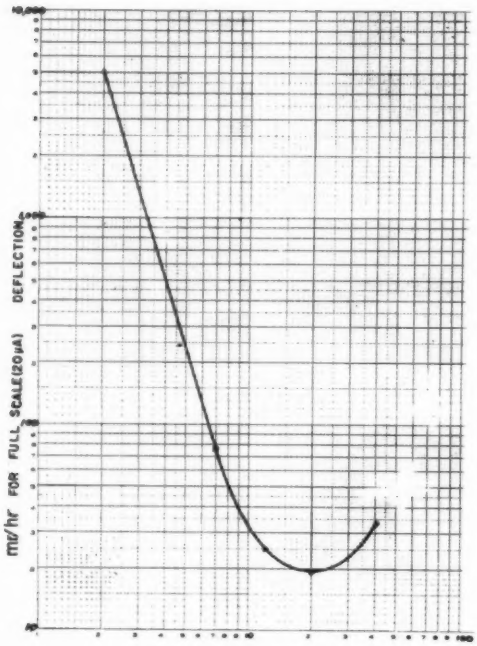

Fig. 1. CdS detector sensitivity *vs.* light bias.

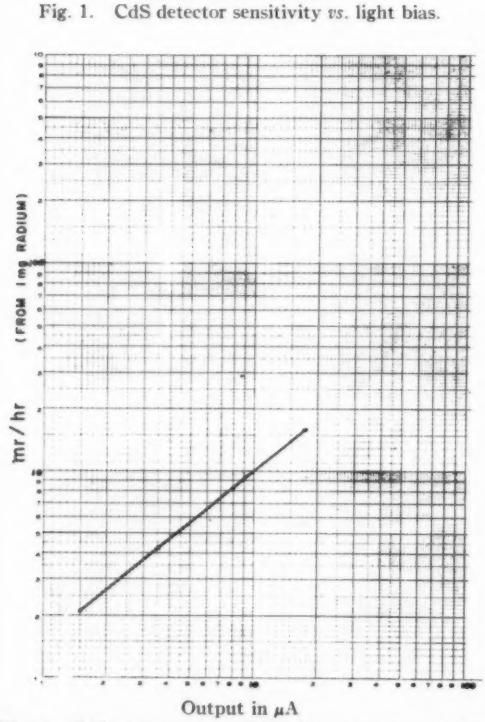

Fig. 3. CdS detector: output in μA *vs.* gamma radiation level in mr/hr.

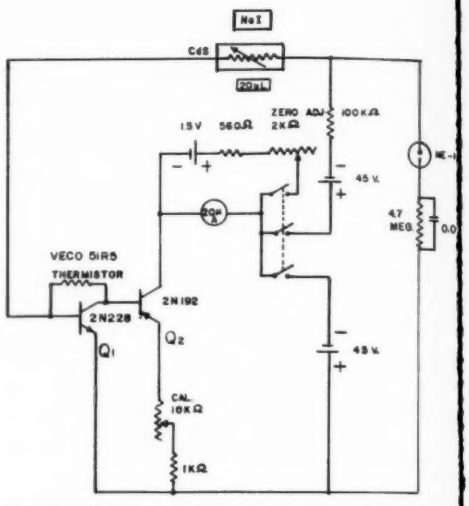

Fig. 2. Schematic representation of photocell and scintillation phosphor radiation detector.

evaporated in a coarse grid design in a plastic resin.

The characteristics of this photoconductive cell are as follows: (1) It has a response peak in the blue-green band around 5,200 A°. The luminous output of the NaI (thallium-activated crystal) roughly overlaps this range when subjected to gamma radiation from radium 226.

(2) The manufacturer's specifications indicate a luminous sensitivity, with 100-volt DC potential, of 4 amperes per lumen. The dark current or noise level is approximately 2×10^{-10} amperes.

A 1 × 1-inch NaI (T1) crystal exposed to a point source of 50 mr/hr. will emit approximately 10^{-5} lumens. The gamma radiation level desired to be detected was in the range from 0.1 to 10 mr/hr. for clinical work. This would involve levels between 10^{-6} and 10^{-7} lumens from the phosphor; 10^{-6} lumens correspond to about 5×10^{-4} foot candles if relative geometries of the cell and phosphor are considered. It is believed that the long-term drift will not interfere with readings of radiation above the level of 2 mr/hr. However, a warm-up time of twenty minutes is required for the CdS cell to reach a stabilized value of conductivity with applied voltage. This could be avoided by applying minimal continuous voltage to the cell.

The decay or return to zero was accomplished by superimposing on the CdS DC bias voltage (90 volts) a short-duration saw-toothed waveform of a noncritical frequency of approximately 100 cps and 2.5 volts in amplitude.

Since the rise-time of the response of the CdS cell is a function of total incident light, the use of a fluorescent light disk bias of 20 microlamberts was found to provide a good compromise between rise-time and sensitivity. This produces an effective

noise current of 12×10^{-6} amperes. The sensitivity *versus* light bias characteristics is shown in Figure 1.

A two-stage direct-coupled transistor amplifier (Fig. 2) performs the dual purpose of matching the 6.0 megohm input impedance and providing 40 decibel gain. The output (Fig. 3) is indicated on a 20-microampere movement with a separate bias battery for balancing out the noise current.

This unit consumes 1.5 milliwatts for the meter-balance circuit, 1.8 milliwatts for the relaxation oscillator, and 42 milliwatts to operate the transistors for a total input of 45.3 milliwatts.

[1] From the Physics Laboratory, Radioisotope Service, VA Hospital, Hines, Ill.

Spectra of Scattered Radiation at Points off the Beam Axis[1]

D. V. CORMACK and S. MAK

Most of the measurements of scattered radiation spectra made up to the present time have been for points on the central axis of a circular beam (1, 2, 3). Measurements made in this geometry are easy to analyze, since the spectrum is independent of the angle, ϕ, of rotation about the beam axis, and depends for a given point in the scatterer only upon the scattering angle, θ. In our laboratory, a scintillation spectrometer has been adapted so that it can be rotated about an axis parallel to the axis of the radiation beam in order to obtain spectra for conditions where there is no radial symmetry. Using this arrangement, we have obtained spectra for various combinations of θ and ϕ for points off the axis of a circular beam from a 280-kvp machine (primary h.v.l. 2.5 mm. Cu). A double numerical integration was then performed to find the total scattered spectrum at these points. It was found that both the shape and the magnitude of the scattered spectrum were nearly constant across the beam, except for points within about 1 cm. from the edge. Spectra were also obtained for points outside the primary beam and were found to be similar in shape to the spectra inside the beam but reduced in magnitude.

REFERENCES

1. CORMACK, D. V., GRIFFITH, T. J., AND JOHNS, H. E.: Brit. J. Radiol. **30**: 129, March 1957.
2. CORMACK, D. V., DAVITT, W. E., BURKE, D. G., AND RAWSON, E. G.: Brit. J. Radiol. To be published.
3. HETTINGER, G., AND STARFELT, N.: Arkiv f. Fysik, 1958. To be published.

[1] From the University of Saskatchewan, Saskatoon, Canada.

EDWARD O. LAWRENCE

1901 1958

EDITORIAL

E. O. Lawrence—A Great Physicist's Influence on Medicine

Ernest Orlando Lawrence, physicist extraordinary, had an influence on medical science that is as unique as his influence in his own special field. This resulted not only from his scientific accomplishments but even more from his tremendous interest in medicine and biology, and his strong desire to have any medical implications of modern physics applied in fields of research associated with medicine and in the practice of medicine. As soon as he had succeeded in making the 37-inch cyclotron operate, he invited medical consultation regarding its possible application to the treatment of human cancers and, with the expenditure of considerable effort, modified his apparatus so that it could be utilized for that purpose. This application of his work required a great deal of his time and that of the laboratory and its personnel which would otherwise have been devoted to physical investigations. Nothing was too much trouble when it involved a medical application of the development in the laboratory.

Dr. Lawrence was also deeply interested in the protection of personnel working with him in the Radiation Laboratory, and the first experiments to determine the relative biological effectiveness of neutrons were done with his encouragement.

Even before the cyclotron was perfected, he had applied another development in his laboratory, namely the Sloan high-frequency x-ray generator, to the needs of medicine, and had had one of the first million-volt x-ray machines installed in the University of California Hospital. It was first used for treating patients in 1934.

Lawrence's 60-inch cyclotron was known as the "medical cyclotron" and a great deal of the thought and planning in the development of this instrument was directed toward the medical application of the beam of fast neutrons and the production of radioisotopes. It must be recorded that in all of his work Dr. Lawrence himself took the initiative and enthusiastically supported biological and medical research and regular treatment of patients. Just as in physics he had introduced bold new ideas of size of projects and teams of workers, so he influenced medicine with the optimistic approach that, if a problem was worth doing, the money, time of personnel, and the size of equipment should not obstruct the path of advancement.

When in the prewar period the cyclotron was the first and only source of artificial radioactive materials, Lawrence arranged for the laboratory to make available as many of these materials as possible to the doctors and other scientists engaged in biological research. With his characteristic generosity he made them available not only to workers in his own laboratory but to scientists in all parts of the world. He welcomed biologic research workers into his laboratory just as warmly and enthusiastically as he did the physicists. Glenn T. Seaborg, writing in *Science*,[1] stated, "Lawrence's catholic interests made him a dedicated disciple of the new concept of interdisciplinary collaboration, and nowhere did such research flourish more than in his laboratory." It is obvious that this interdisciplinary collaboration extended well beyond the physical sciences and that it had a tremendous impact on biology and medicine.

In the Radiation Laboratory created by Lawrence and attributable to his leader-

[1] SEABORG, G. T.: E. O. Lawrence—Physicist, Engineer, Statesman of Science. Science 128: 1123–1124, Nov. 7, 1958.

ship, hundreds of radioactive isotopes were discovered and identified, such as carbon 14, iodine 131, tritium, etc. Seaborg said: "His cyclotron is to nuclear science what Galileo's telescope was to astronomy." It can with equal surety be said that his radioisotopes were to biological and medical research what the microscope was to the same sciences in an earlier period. They have provided us with a tool to look inside the cell, to study physiological processes previously mysterious to us, to diagnose disturbed metabolic conditions, and to treat some types of malignant disease. The course of medicine has been greatly altered as the result of the radioactive elements.

Lawrence's interest in biology and medicine was not theoretical or limited to the encouragement of others. His name appears on nine publications relating biology and medicine to the new nuclear physics, and he gave several addresses, such as one to the Radiological Society of North America, on "The Biological Action of Neutron Rays." Some of his colleagues felt that he was even more gratified with his discoveries when applied to medicine than when applied to pure physics.

A fundamental factor in the achievements of Ernest Lawrence was his warm character and great energy. Seaborg aptly said that "he had the vision to glimpse the limitless nature of the horizon and the generosity to make room for others. His personal credo was, 'There is enough research for all of us to do.' He interceded, with his rare persuasiveness, to create new facilities for worthy projects. He rejoiced as jubilantly in the success of others as in his own. As a result, the careers of many scientists . . .are founded on his large contributions and his generous nature."

Lawrence was a critical figure in the success of the atomic bomb project in World War II, and his influence was large in the decision to develop the hydrogen bomb and to maintain our nuclear strength in the absence of strong international guarantees. He was gravely concerned for the safety of the free institutions that shelter the spirit of true scientific inquiry. On the other hand, he felt deeply the demand to work toward peace through realistic international control of the weapons that the new knowledge had created. It can be said that the new knowledge was neither warlike nor peaceful in essence, nor was it intrinsically good or evil. It was a tool that man could use one way or another. Even though ill, he went to Geneva to try to assure that this knowledge would not be used for war. In this sense, he gave his life for peace.

Ernest Orlando Lawrence was born in the village of Canton, South Dakota, on Aug. 8, 1901, the second generation product of educated Norwegian immigrants. He received his preliminary education in St. Olaf College and the University of South Dakota, going from there to the University of Minnesota, the University of Chicago, and Yale University, where he received his Ph.D. degree in 1925. At the age of twenty-nine he became the youngest full professor on the faculty of the University of California at Berkeley and from then on rushed to explore the new world of the opening atom.

Doctor Lawrence received many honors during his life-time, the more important being the Nobel prize for physics in 1939, the Faraday medal, named for the great English pioneer in physical science, the Comstock prize of the National Academy of Science, the Medal for Merit of the U. S. Government, the American Cancer Society medal for contributions to the fight against that dread disease, and the Enrico Fermi medal of the Atomic Energy Commission. He held many honorary degrees and honorary memberships in domestic and foreign societies.

In summarizing Lawrence's overall contribution to the world, Dr. Clark Kerr, President of the University of California, said:

"Man-like creatures have lived on this planet for at least a million years. Throughout these million years they have constantly groped to understand more

about and to control better the world about them. A few of them have shot some ray of light into the great unknown darkness of ignorance and illuminated a new era for all future generations. One of the strongest of these beams of light was created by Ernest Lawrence, and men forever after will see farther and understand more because of it. Each of us and each of our children owe to Ernest Lawrence a debt beyond price. For by his expansion of our understanding, by his reduction of our ignorance, he has added a little to the human dignity of each of us and something more to the meaning of life."

Although he died on Aug. 27, 1958, Doctor Lawrence's spirit lives on in the laboratory he created, in the hundreds of young scientists he stimulated, and in the many institutions where the results of his work will permit a deeper penetration of biological processes and result in the better health of mankind.

ROBERT S. STONE, M.D.

ANNOUNCEMENTS AND BOOK REVIEWS

FLORIDA WEST COAST RADIOLOGICAL SOCIETY

At a meeting at the Tampa Terrace Hotel in Tampa, Oct. 15, 1958, the Florida West Coast Radiological Society was formed. The group includes the 32 radiologists from the Tampa, St. Petersburg, Lakeland, Clearwater, Sarasota, and Fort Myers area. The officers of the new organization are: Charles Gray, M.D., Tampa, President; Thomas Dorr, M.D., Tampa, Vice-President; Joseph C. Rush, M.D., 1501 Jungle, St. Petersburg, Secretary-Treasurer.

SAN FRANCISCO RADIOLOGICAL SOCIETY

Newly elected officers of the San Francisco Radiological Society are: President, Earl Miller, M.D.; President-Elect, J. F. Huffman, M.D.; Directors, J. T. English, M.D., and J. C. Bennett, M.D.; Secretary-Treasurer, M. A. Sisson, M.D., 450 Sutter St., San Francisco 8.

TRI-STATE RADIOLOGICAL SOCIETY

Recently elected officers of the Tri-State Radiological Society, all from Evansville, Indiana, are: E. L. Hendershot, M.D., President; Robert E. Beck, M.D., President-Elect; James R. Mathews, M.D., 118 S. E. First St., Secretary-Treasurer.

UTAH STATE RADIOLOGICAL SOCIETY

At a recent meeting of the Utah State Radiological Society, the following officers, all from Salt Lake City, were elected for the coming year: President, Ralph R. Meyer, M.D.; Vice-President, Philip Frederick, M.D.; Secretary-Treasurer, Wm. R. Christensen, M.D., 2033 S. State St., Salt Lake City 15. Dr. Christensen was also chosen Councilor to the American College of Radiology.

WISCONSIN RADIOLOGICAL SOCIETY

Newly elected officers of the Wisconsin Radiological Society are: President, S. Richard Beatty, M.D., Neenah; President-Elect, Robert W. Byrne, M.D., Milwaukee; Secretary-Treasurer, Farrell F. Golden, M.D., 5221 Tonyawatha Trail, Madison 4.

AMERICAN CLUB OF THERAPEUTIC RADIOLOGISTS

At the recent meeting of the Radiological Society of North America, in Chicago, the American Club of Therapeutic Radiologists, consisting of some one hundred members, was organized for the exchange of ideas and experiences. The new organization contemplates no separate meetings or special publications but will meet for dinner on the occasion of the annual meetings of the Radiological Society of North America and the American Radium Society. The following officers were elected: Simeon T. Cantril, M.D., Seattle, President; J. W. J. Carpender, M.D., Chicago, Vice-President; Juan A. del Regato, M.D., 2200 North Cascade Ave., Colorado Springs, Colo., Secretary.

INTER-AMERICAN COLLEGE OF RADIOLOGY

At the meeting of the Inter-American College of Radiology Nov. 2–8, 1958, in Lima, Peru, the following officers, all of Havana, Cuba, were elected: President, Dr. J. Manuel Viamonte, Sr.; Secretary, Dr. Laura S. Fariñas, Calle 23 No. 411, Vedado, Havana; Treasurer, Dr. Eduardo Rivero. Brazil was chosen as the headquarters of the Inter-American Congress for 1961.

At a special convocation of the American College of Radiology held at the time of the meeting in Lima, the following were awarded honorary fellowships: Dr. Agustín Castellanos of Havana; Dr. Narno Dorbecker of Mexico; Dr. Pedro Gonzales Rincones of Caracas; Dr. Mathias Roxo-Nobre of Brazil; Dr. Vicente Ubillus of Lima. Dr. Oscar Soto, President of the Congress, was awarded a special diploma of honor in the same ceremony.

EASTERN CONFERENCE OF RADIOLOGISTS

The Eastern Conference of Radiologists will meet at the Statler Hotel in Washington, D. C., March 19–21, 1959. The host for this meeting will be the Section on Radiology of the Medical Society of the District of Columbia. A balanced scientific program will be presented with equal emphasis on the diagnostic and therapeutic aspects of radiology. A special clinic on therapy problems will be presented at the Walter Reed Army Medical Center. As an added note of interest, a trip has seen arranged to the nuclear reactor at the National Naval Medical Center in Bethesda.

The social program will begin with a cocktail party on Thursday, March 19. A cocktail party and dinner dance will be held on the following day. Special arrangements are being made for the entertainment of the ladies during the scientific sessions. Further information may be obtained from Dr. U. V. Wilcox, II, 915 19th Street, N. W., Washington 6, D. C.

INTERNATIONAL COURSE ON TOMOGRAPHY

The Fourth International Course on Tomography will be held in September or October 1959, at the

Institute of Radiology of the University of Genoa, Italy, under the direction of Professor Alessandro Vallebona. While all lectures will be delivered in the original language, they will be simultaneously translated into Italian, French, English, German, and Spanish. Those interested in attending this Course may obtain further information from Professor Neopolo Macarini, General Secretary, Istituto di Radiologia della Università, Ospedale San Martino, Genoa, Italy.

COURSE IN RADIATION HYGIENE MEASUREMENTS

A four-week course in Radiation Hygiene Measurements will be given at the New York University-Bellevue Medical Center Institute of Industrial Medicine, May 4–29, 1959. This is one in a series of four courses conducted by the Post-Graduate Medical School of the University in co-operation with the Atomic Energy Commission (Health and Safety Laboratory), the other three courses having been given in November 1958 and January 1959.

The course will include radiation surveying and monitoring in the field of medical and dental radiology, as well as the use of radioisotopes. The tuition fee is $180.00.

Further information may be obtained from the Office of the Associate Dean, New York University Post-Graduate Medical School, 550 First Ave., New York 16, N. Y.

DIAGNOSTIC RADIOLOGY COURSE

The second annual postgraduate course in diagnostic radiology will be presented March 20–24, 1959, under the auspices of the University of California Medical Center, San Francisco. In addition to members of Stanford University and the University of California Departments of Radiology, the faculty will include Dr. Felix Fleischner, Harvard Medical School, Dr. Benjamin Felson, University of Cincinnati College of Medicine, Dr. John Hope, The Children's Hospital, Philadelphia, and Dr. Leo G. Rigler, University of California School of Medicine, Los Angeles.

Further details of the course may be obtained by addressing Continuing Medical Education, University of California Medical Center, San Francisco 22, Calif.

Books Received

Books received are acknowledged under this heading, and such notice may be regarded as recognition of the courtesy of the sender. Reviews will be published in the interest of our readers and as space permits.

PROGRESS IN RADIATION THERAPY. Edited by FRANZ BUSCHKE, M.D., Professor of Radiology, University of California School of Medicine, San Francisco. With 13 contributors. A volume of 284 pages, with figures and tables. Published by Grune & Stratton, Inc., New York, 16, 1958. Price $9.75.

TUMORS OF THE LUNGS AND MEDIASTINUM. By B. M. FRIED, M.D., F.C.C.P., Associate Attending Physician, Montefiore Hospital; Associate Visiting Physician, Morrisania City Hospital, New York, N. Y. A volume of 468 pages, with 340 black and white illustrations on 231 figures, and 4 in color on 2 plates. Published by Lea & Febiger, Philadelphia, 1958. Price $13.50.

ANNUAL REVIEW OF NUCLEAR SCIENCE. VOLUME 8. Editor: EMILIO SEGRÈ, University of California. Associate Editors: GERHART FRIEDLANDER, Brookhaven National Laboratory, and WALTER E. MEYERHOF, Stanford University. A volume of 418 pages, with charts and tables. Published by Annual Reviews, Inc., in co-operation with the National Research Council of the National Academy of Sciences, 1958. On sale by Annual Reviews, Inc., Palo Alto, Calif. Price $7.00 (U. S. A.); $7.50 (elsewhere).

ORGANIC PEROXIDES IN RADIOBIOLOGY (LES PEROXYDES ORGANIQUES EN RADIOBIOLOGIE). COLLOQUIUM ON ORGANIC PEROXIDES FORMED BY RADIATIONS AND THEIR RÔLE IN RADIOBIOLOGY, INSTITUT DU RADIUM, PARIS, 9 AND 10 JANUARY 1957. By R. LATARJET ET AL. General Editor: M. HAÏSSINSKY. A volume of 154 pages, with numerous figures and tables. Published by Pergamon Press, Inc., 122 East 55th St., New York 22, N. Y., 1958. (Published simultaneously in France by Masson & Cie, 120, Blvd. Saint-Germain, Paris, 6°.) Price $9.50.

THE SELLA IN HEALTH AND DISEASE: THE VALUE OF THE RADIOGRAPHIC STUDY OF THE SELLA TURCICA IN THE MORBID ANATOMICAL AND TOPOGRAPHIC DIAGNOSIS OF INTRACRANIAL TUMOURS. By MAHMOUD EL SAYED MAHMOUD, Ph.D. Rad., M.B., B.Ch., D.M.R.E. A thesis approved by the University of London for the award of the degree of Doctor of Philosophy. British Journal of Radiology Suppl. No. 8. A monograph of 100 pages, with 120 figures and 9 tables. Published by the British Institute of Radiology, 32 Welbeck Street, London, W. 1, England, 1958.

STUDIES ON THE EFFECT OF THYROTROPIC HORMONE ON THE THYROID FUNCTION IN MAN. By JERZY EINHORN. From Radiumhemmet, Karolinska Sjukhuset, Stockholm 60, Sweden. Acta Radiologica Suppl. 160. A monograph of 108 pages, with 23 figures and 22 tables. Published by Acta

Radiologica, Stockholm 2, Sweden, 1958. Price Sw. Kr. 30:—

THE VASCULAR ANATOMY OF LONG BONES: A RADIOLOGICAL AND HISTOLOGICAL STUDY. By GUNNAR TILLING. From the Roentgen Department, University Hospital, Uppsala, Sweden, and from the Histological Department, University of Uppsala, Sweden. Acta Radiologica Suppl. 161. A monograph of 108 pages, with 47 figures. Published by Acta Radiologica, Stockholm 2, Sweden, 1958. Price Sw. Kr. 25:—

RENAL ANGIOGRAPHY DURING AND AFTER UNILATERAL URETERIC OCCLUSION: A LONG-TERM EXPERIMENTAL STUDY IN DOGS. By TORSTEN WIDÉN. From the Roentgen-Diagnostic Department, University Hospital, Lund, and the Malmö Department of Surgery of the University of Lund, Sweden. Acta Radiologica Suppl. 162. A monograph of 104 pages, with 37 figures. Published by Acta Radiologica, Stockholm 2, Sweden, 1958. Price Sw. Kr. 30:—

NEPHROGRAPHIC EFFECT AND RENAL ARTERIOGRAPHIC DAMAGE: AN EXPERIMENTAL STUDY. By CARL-GUSTAF HELANDER. From the Roentgen Diagnostic Department, Karolinska Sjukhuset, Stockholm, Central Clinical Laboratory, St. Erik's Hospital, Stockholm, The Department of Pathology II, University, Upsala, Departments of Medicine and Roentgenology, Veterinärhögskolan, Stockholm, Sweden. Acta Radiologica Suppl. 163. A monograph of 88 pages, with 20 figures and 14 tables. Published by Acta Radiologica, Stockholm 2, Sweden, 1958. Price Sw. Kr. 30:—

CONGENITAL ATRESIA OF THE SMALL INTESTINE: A ROENTGENOGRAPHIC STUDY OF 24 CASES. By H. GLADNIKOFF. From the Roentgen Department, Sachska Barnsjukhuset, Stockholm, Sweden. Acta Radiologica Suppl. 164. A monograph of 58 pages, with 19 figures and 1 table. Published by Acta Radiologica, Stockholm 2, Sweden, 1958. Price Sw. Kr. 25:—

COARCTATION OF THE AORTA: AORTOGRAPHIC STUDIES BEFORE AND AFTER OPERATION. By BROR BRODÉN AND JOHAN KARNELL. From Roentgen Department I and the Heart Clinic, Södersjukhuset, Stockholm, Sweden. Acta Radiologica Suppl. 165. A monograph of 62 pages, with 37 figures and 4 tables. Published by Acta Radiologica, Stockholm 2, Sweden, 1958. Price Sw. Kr. 30:—

L'ANGIOGRAPHIE CÉRÉBRALE. By JOËL BONNAL, Neurochirurgien assistant de la Clinique Neurochirurgicale de la Faculté de Médicine de Marseille, and Jacques Legré, Electroradiologiste des Hôpitaux de Marseille. Travail de la Clinique Neurochirurgicale de la Faculté de Médecine de Marseille et du Service Central de Radiologie de l'Hôpital de la Timone. Preface by P^r J. E. Paillas. A volume of 254 pages, with 223 figures. Published by Masson & Cie, 120, Boulevard Saint-Germain, Paris 6^e, 1958. Price 6,000 fr.

Book Reviews

TUMORS AND TUMOROUS CONDITIONS OF THE BONES AND JOINTS. By HENRY L. JAFFE, M.D., Director of Laboratories and Pathologist, Hospital for Joint Diseases, New York, N. Y., Consultant, Armed Forces Institute of Pathology, Washington, D. C. A volume of 630 pages, with 701 illustrations on 194 figures. Published by Lea & Febiger, Philadelphia, 1958. Price $18.50.

Tumors and Tumorous Conditions of the Bones and Joints, as used here, is a comprehensive title. The author is concerned not only with the usual tumors which are primary in the bone but also with those which are metastatic. In addition, consideration is given to tumors which invade bone from adjacent soft-tissue tumors, pre-existing bone disease, and the joint structures.

A thorough discussion of the clinical features, the roentgen findings, the pathologic manifestations, the differential diagnostic possibilities, and the broad therapeutic principles is presented under each disease entity. The pathologic findings are given in somewhat full detail, reflecting the author's interest and experience. The text is clearly written and presents a well rounded story of the lesions being discussed. Numerous roentgenograms and photographs show both the gross and microscopic findings. The legends describing the lesions constitute a valuable commentary.

This is an unusually valuable book, presenting a well balanced authoritative discussion of an old subject with many new aspects. It should be of unusual interest to radiologists, pathologists, and surgeons who are interested in the skeletal system.

THE CERVICAL SYNDROME. By RUTH JACKSON, B.A., M.D., F.A.C.S., Clinical Assistant Professor of Orthopaedic Surgery, The University of Texas, Southwestern Medical School, Dallas; Attending Orthopaedic Surgeon, Baylor University Hospital; formerly Chief of Orthopaedic Surgery, Parkland Hospital, and Instructor in Orthopaedic Surgery, Baylor University College of Medicine, Dallas, Texas. A volume of 198 pages, with 90 figures. Published by Charles C Thomas, Springfield, Ill., 2d ed., 1958. Price $6.50.

In this monograph the author presents the anatomic and basic factors which underlie the so-called cervical syndrome. Considerable stress is placed

upon proper knowledge of the anatomy of the area, while many drawings and radiographs demonstrate the main points of diagnosis and treatment.

The author has devoted years of study to her subject and her book is a timely one for all clinicians and radiologists. Special mention may be made of the discussion of whiplash injuries.

ROENTGENDIAGNOSTICS. PROGRESS VOLUME I. By H. R. SCHINZ, R. GLAUNER, AND E. UEHLINGER. With the collaboration of W. E. Baensch, J. E. W. Brocher, U. Cocchi, R. Glocker, W. Hess, R. Janker, O. Norman, R. Prévot, G. Schoch, E. Uehlinger, S. Welin, J. Wellauer, E. Zdansky. Translated from the German by James T. Case, M.D., D.M.R.E. (Cambridge). A volume of 624 pages, with 545 figures containing 892 illustrations. Published by Grune & Stratton, Inc., New York 16, N. Y., 1958. Price $35.00.

In this *Progress Volume* the authors present a comprehensive review of the research in roentgen diagnosis which appeared between 1952 and 1956. The English translation is by Dr. James T. Case, who was responsible for the American edition of the four-volume *Lehrbuch der Roentgendiagnostik*, and forms a valuable supplement to that outstanding work.

The material presented covers most of the body systems. It is, however, largely weighted by the newer work on angiography, which has developed so rapidly in recent years. Chapters are also devoted to certain aspects of the spine, bone tumors, lungs, gastrointestinal tract, cholangiography, and hystero-salpingopelvigraphy.

The text is amply illustrated with well chosen radiographs and photographs. A pertinent bibliography is included at the end of each chapter. Dr. Case has added in his translation references through most of 1957, so that bibliographically the American edition is even more up to date than the German original.

This book is an especially valuable addition to the library of the radiologist because it presents most of the newer research work which, after evaluation by the authors, has been deemed to be sound and reliable. The English translation is excellent and clearly conveys the original thought of the German text.

RADIOACTIVE ISOTOPES IN CLINICAL PRACTICE. By EDITH H. QUIMBY, Sc.D., Professor of Radiology (Physics), College of Physicians and Surgeons, Columbia University, New York; SERGEI FEITELBERG, M.D., Director, Physics Department, The Mount Sinai Hospital; Associate Clinical Professor of Radiology, College of Physicians and Surgeons, Columbia University, New York; and SOLOMON SILVER, M.D., Attending Physician; Chief, Thyroid Clinic, The Mount Sinai Hospital; Associate Clinical Professor of Medicine, College of Physicians and Surgeons, Columbia University, New York. A volume of 452 pages, with 97 figures. Published by Lea & Febiger, Philadelphia, 1958. Price $10.00.

This work is the outgrowth of a radioisotope course given twice a year for the last four years, each of the three sections being written by the author who had most to do with presenting that field in the course.

The first section, by Dr. Quimby, deals with the basic physics of radioisotopes and their radiations. Included are considerations of dosage calculations, biological effects, radiation hazards and protection, and disposal of radioactive wastes.

The second section, by Dr. Feitelberg, is devoted to instrumentation and laboratory methods. The discussion is practical. It deals with a clinical, rather than a research isotope laboratory.

In the last section, Dr. Silver discusses clinical applications, with considerable space devoted to the use of I^{131} in the diagnosis and treatment of thyroid disease. This emphasis is appropriate, since a majority of readers will be especially interested in this subject. Other diagnostic and therapeutic uses are not neglected, however.

The book closes with an Appendix containing physical data which will be useful to anyone engaged in medical use of isotopes.

The wide experience of the authors in this field, both in research and in teaching, is apparent in the well organized, practical text, with its clear discussions. This book will doubtless be used as a textbook by residents and radiological physicists in training, as well as a reference book for those already in the field. No one using isotopes will want to be without it.

PRINCIPLES OF RADIOGRAPHIC EXPOSURE AND PROCESSING. BY ARTHUR W. FUCHS. A volume of 284 pages, with 159 figures and 24 tables. Published by Charles C Thomas, Springfield, Ill., 2d ed., 1958. Price $10.50.

This book is devoted to the broad principles of radiographic technic and film processing. It does not attempt to demonstrate roentgen anatomy or the details of positioning. The text is divided into two parts. Part 1 deals with radiographic exposure, including the production of the film and its properties, image formation, and the variables that contribute to its production. Many experiments are reported to show the function of these variables. In Part 2 the problems relating to film processing are discussed in detail, with emphasis on the proper handling of films both before and after exposure. Considerable emphasis is placed on the chemical factors which are involved.

The authenticity of this work is attested by the distinguished background of the author. His book will be in great demand both as a reference and teaching guide. It will be especially valuable in schools of radiographic technic.

ARTERIOGRAFIA ADDOMINALE E DELLE ESTREMITÀ. IN APPENDICE: ARTERIOGRAFIA TIROIDEA. By ANTONIO RABAIOTTI, Assistente, Istituto di Radiologia, Ospedale Riuniti di Parma, LUCIO ROSSI, Assistente, Istituto di Radiologia, Università di Ferrara, and GIORGIO PREVEDI, Aiuto, Istituto di Radiologia, Ospedali Riuniti di Parma. A volume of 468 pages, with 202 figures. Published by Edizioni Minerva Medica, Turin, Italy, 1956. Price 7,500 lire.

The printing of this book was completed late in December 1956, and it represents the experiences accumulated during a decade of use of abdominal and peripheral arteriography, as a joint enterprise of the Surgical, Gynecological, and Roentgenological Departments of the University of Parma. A crystal-clear text, with precise technical details for all procedures, it is obviously intended to permit their duplication by any interested reader. Artistic reproductions on luxurious paper (though not too well bound) enhance notably the value of the presentation. A 49-page bibliography of about 1,500 titles, with uniform indications (including volume and page number, as well as year of publication) concludes this work, which appears to be an adequate illustration of the constant improvement in the seriousness of scientific endeavor and level of research among Italian investigators.

Of particular interest is the addendum, which presents a new technic, intended for the demonstration of the circulation in the thyroid gland. The procedure consists of percutaneous injection into the subclavian (after application of a tourniquet on the arm, as close as possible to the axilla) of 20 c.c. of a 70 per cent tri-iodinated medium, at the speed of 5 c.c. per second. The contrast material penetrates into the branches of the subclavian in a retrograde fashion. Within the thyroid, as in all other locations, one may observe three phases, arterial, capillary, and venous. In early stages of thyroid tumor, the inferior thyroid artery appears dilated and shows a sudden interruption at the margin of the tumor, with multiple, serpiginous branches entering the neoformation. This is only a preliminary presentation, but the procedure seems to have merit, and subsequent publications on this subject may be expected.

AMERICAN BOARD OF RADIOLOGY EXAMINATION

The American Board of Radiology will conduct an examination June 2–4, 1959, at the Palmer House, Chicago. The deadline for filing applications for this examination is Feb. 15, 1959.

If sufficient interest is shown, a special examination will be offered at that time in Nuclear Medicine, open to diplomates in Radiology or Therapeutic Radiology. The deadline for making application for this examination is April 1, 1959.

H. DABNEY KERR, M.D.
Secretary, American Board of Radiology

IN MEMORIAM

RAYMOND G. TAYLOR, M.D.

1872–1958

On June 29, 1958, Raymond G. Taylor, M.D., a former president of the Radiological Society of North America (1939) and pioneer Los Angeles radiologist, passed away following a prolonged illness. Doctor Taylor was born in Sycamore, Illinois, on February 15, 1872, and spent his boyhood in Sycamore and Rockford, Illinois, and Sioux Falls, South Dakota. In October 1889, at the age of seventeen, he moved to California with his parents, who settled near Covina, in the San Gabriel Valley.

After graduation from the University of Southern California Medical School in 1896, he interned in the County Hospital, of which he was appointed assistant superintendent in 1897. There he set up the first clinical laboratory in the hospital and started a museum of pathology and systematic autopsy service. In 1900, Doctor Taylor established a private medical practice in Los Angeles. He was active in the County Medical Association and served as its secretary from 1905 through 1907. He became president in 1908 at the age of thirty-five, the youngest man to be so honored.

In 1908, Doctor Taylor and two other physicians contracted with the city of Los Angeles to supply medical supervision, personnel, and equipment for the Owens Valley Aqueduct Project for bringing

water to Los Angeles. Doctor Taylor eventually took over the entire contract and served until the aqueduct was completed in February 1913. Following this, for a period of about three years, he was chief surgeon of the Los Angeles city departments, including water and power.

Sometime in 1915, Doctor Taylor went into practice with his cousin, a surgeon. Their interest in barium gastrointestinal x-ray examinations, which were not then available in Los Angeles, stimulated him to take a postgraduate course in radiology at the Massachusetts General Hospital during the summer of 1917. There was no adequate x-ray service at the Los Angeles County Hospital at that time, and Doctor Taylor in order to acquire more experience offered to take charge of this service for $75.00 a month. The demand for examinations became so great that he found it necessary to recruit and train technicians and add more and more equipment. A year later, he resigned as radiologist at the County Hospital to become radiologist at the Hospital of the Good Samaritan, Los Angeles. For a few years (1923 to 1929), he also maintained a private office for the practice of radiology but subsequently closed it in order to serve better the growing department at the hospital.

Doctor Taylor was an example of the true consulting radiologist—he accepted only patients referred by physicians and undertook whatever form of radiologic examination was necessary to obtain the information desired. Finally, he reviewed the films and discussed his findings with the clinician as a real consultant. He steadfastly resisted with limited success the attempts of insurance companies to base fees on a minimum type of examination.

Because of Doctor Taylor's early experience with contract and industrial medicine, he was keenly interested in related problems concerning radiology. He joined the Radiological Society of North America in 1922 and soon became active in the society's affairs because of his background in industrial and organization matters. In 1939, he was elected the twenty-fourth president of this society.

In 1947, Doctor Taylor retired as head of the department of radiology at the Hospital of the Good Samaritan. His retirement years were spent in compiling data for his *Recollection of Sixty Years of Medicine in Southern California*. These historical memoirs were privately printed shortly before his death. They record, in Doctor Taylor's forthright manner, a rich collection of facts and informal anecdotes associated with the growth of medicine from the "horse and buggy days" in California, and the organization and growth of the various national radiological societies.

Doctor Taylor is survived by a daughter Zada; two sons, Raymond, Jr., and Robert W.; a sister Mrs. Bess Edwards; nine grandchildren and one great-grandchild. Another son, Richard, also a radiologist, died in 1955.

RADIOLOGICAL SOCIETIES: SECRETARIES AND MEETING DATES

Editor's Note: Secretaries of state and local radiological societies are requested to co-operate in keeping this section up-to-date by notifying the editor promptly of changes in officers and meeting dates.

RADIOLOGICAL SOCIETY OF NORTH AMERICA. *Secretary-Treasurer*, Donald S. Childs, M.D., 713 E. Genesee St., Syracuse 2, N. Y.

AMERICAN RADIUM SOCIETY. *Secretary*, Robert L. Brown, M.D., P. O. Box 459, Emory University, Ga.

AMERICAN ROENTGEN RAY SOCIETY. *Secretary*, C. Allen Good, M.D., Rochester, Minn.

AMERICAN COLLEGE OF RADIOLOGY. *Exec. Secretary*, William C. Stronach, 20 N. Wacker Dr., Chicago 6.

AMERICAN CLUB OF THERAPEUTIC RADIOLOGISTS. *Secretary*, Juan A. del Regato, M.D., 2200 North Cascade Ave., Colorado Springs, Colo.

ASSOCIATION OF UNIVERSITY RADIOLOGISTS. *Secretary-Treasurer*, Paul A. Riemenschneider, M.D., 736 Irving Ave., Syracuse 10, N. Y.

SECTION ON RADIOLOGY, A. M. A. *Secretary*, T. Leucutia, M.D., 10 Peterboro, Detroit 1, Mich.

SOCIETY OF NUCLEAR MEDICINE. *Secretary*, Robert W. Lackey, M.D., 452 Metropolitan Bldg., Denver 2, Colo.

Alabama

ALABAMA RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, J. Garland Wood, Jr., M.D., Medical College of Alabama, Birmingham 3.

Arizona

ARIZONA RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, R. Lee Foster, M.D., 1313 N. Second St., Phoenix. Annual meeting with State Medical Association; interim meeting in December.

Arkansas

ARKANSAS RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, E. A. Mendelsohn, M.D., Holt-Krock Clinic, Fort Smith. Meets quarterly.

California

CALIFORNIA MEDICAL ASSOCIATION, SECTION ON RADIOLOGY. *Secretary*, William H. Graham, M.D., 630 E. Santa Clara St., San Jose.

EAST BAY ROENTGEN SOCIETY. *Secretary*, Dan Tucker, M.D., 434 30th St., Oakland 9. Meets monthly, first Thursday, at Peralta Hospital.

LOS ANGELES RADIOLOGICAL SOCIETY. *Secretary*, Robert B. Engle, M.D., St. Luke Hospital, Pasadena. Meets second Wednesday, September, November, March, April, and June, Los Angeles County Medical Association Building.

NORTHERN CALIFORNIA RADIOLOGICAL SOCIETY. *Secretary*, Rob H. Kirkpatrick, M.D., 1219 28th St., Sacramento 16. Meets last Monday of each month, September through June.

PACIFIC ROENTGEN SOCIETY. *Secretary*, L. Henry Garland, M.D., 450 Sutter St., San Francisco 8. Meets annually at time of California State Medical Association convention.

RADIOLOGICAL SOCIETY OF SOUTHERN CALIFORNIA. *Secretary-Treasurer*, Harold P. Tompkins, M.D., 658 S. Westlake, Los Angeles 57.

REDWOOD EMPIRE RADIOLOGICAL SOCIETY. *Secretary*, Lee E. Titus, M.D., 164 W. Napa Street, Sonoma, Calif. Meets second Monday every other month.

SAN DIEGO RADIOLOGICAL SOCIETY. *Secretary*, Stanley A. Moore, M.D., 2466 First Ave., San Diego 1. Meets first Wednesday of each month.

SAN FRANCISCO RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, M. A. Sisson, M.D., 450 Sutter St., San Francisco 8. Meets quarterly, at Grison's Steak House.

SOUTH BAY RADIOLOGICAL SOCIETY. *Secretary*, Stanford B. Rossiter, M.D., 1111 University Dr., Menlo Park. Meets second Wednesday every month.

X-RAY STUDY CLUB OF SAN FRANCISCO. *Secretary*, John H. Heald, M.D., 450 Sutter St., San Francisco 8. Meets third Thursday at 7:30 P.M., Children's Hospital, September through June.

Colorado

COLORADO RADIOLOGICAL SOCIETY. *Secretary*, Lorenz R Wurtzebach, M.D., 601 E. Nineteenth Ave., Denver 5. Meets monthly, third Friday, at Denver Athletic Club.

Connecticut

CONNECTICUT STATE MEDICAL SOCIETY, SECTION ON RADIOLOGY. *Secretary-Treasurer*, Ralph J. Littwin, M.D., Bristol Hospital, Bristol. Meets bimonthly, second Wednesday.

District of Columbia

RADIOLOGICAL SECTION, DISTRICT OF COLUMBIA MEDICAL SOCIETY. *Secretary-Treasurer*, Charles E. Bickham, Jr., M.D., 1835 Eye St., N.W., Washington 6. Meets third Wednesday, January, March, May, and October, 8:00 P.M., in Medical Society Library.

Florida

FLORIDA RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Russell D. D. Hoover, M.D., 1717 N. Flagler Dr., West Palm Beach. Meets in April and October.

FLORIDA WEST COAST RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Joseph C. Rush, M.D., Mease Hospital, Dunedin. Meets third week of October, January, April, and July.

GREATER MIAMI RADIOLOGICAL SOCIETY, *Secretary-Treasurer*, George P. Daurelle, M.D., Jackson Memorial Hospital, Miami 36. Meets monthly, third Wednesday, 8:00 P.M., at Jackson Memorial Hospital.

NORTH FLORIDA RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Marvin Harlan Johnston, M.D., Five Points Medical Center, Jacksonville 4. Meets quarterly, March, June, September, and December.

Georgia

ATLANTA RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, J. Luther Clements, Jr., M.D., 35 Linden Ave., N.E., Atlanta 8. Meets second Friday, September to May.

GEORGIA RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Herbert M. Olnick, M.D., 417 Persons Bldg., Macon, Ga. Meets in November and at the annual meeting of the State Medical Association.

RICHMOND COUNTY RADIOLOGICAL SOCIETY. *Secretary*, Wm. F. Hamilton, Jr., M.D., University Hospital, Augusta. Meets first Thursday of each month.

Hawaii

RADIOLOGICAL SOCIETY OF HAWAII. *Secretary-Treasurer*, Robert G. Rigler, M.D., 1020 Kapiolani St., Honolulu 14. Meets third Monday of each month.

Idaho

IDAHO STATE RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Charles R. McWilliams, M.D., Twin Falls.

Illinois

CHICAGO ROENTGEN SOCIETY. *Secretary-Treasurer*, George B. Cahill, M.D., 802 Burns Ave., Flossmoor, Ill. Meets at the Sheraton Hotel, second Thursday of October, November, January, February, March, and April at 8:00 P.M.

ILLINOIS RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Stephen L. Casper, M.D., Physicians and Surgeons Clinic, Quincy.

ILLINOIS STATE MEDICAL SOCIETY, SECTION ON RADIOLOGY. *Secretary*, William Meszaros, M.D., 1825 W. Harrison St., Chicago.

Indiana

INDIANA ROENTGEN SOCIETY. *Secretary-Treasurer*, Chester A. Stayton, Jr., M.D., 313 Hume Mansur Bldg., Indianapolis 4. Meets twice a year, first Sunday in May and during fall meeting of State Medical Association.

TRI-STATE RADIOLOGICAL SOCIETY (Southern Indiana, Northwestern Kentucky, Southeastern Illinois). *Secretary-Treasurer*, James R. Mathews, M.D., 118 S. E. First St., Evansville, Ind. Meets October, January, March, and May.

Iowa

IOWA RADIOLOGICAL SOCIETY. *Secretary*, James T. McMillan, M.D., 1104 Bankers Trust Bldg., Des Moines. Meets during annual session of State Medical Society, and in the Fall.

Kansas

KANSAS RADIOLOGICAL SOCIETY. *Secretary*, James R. Stark, M.D., 3244 East Douglas St., Wichita 8. Meets in the Spring with the State Medical Society and in the Winter on call.

Kentucky

KENTUCKY RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Robert H. Akers, M.D., 1405 West Broadway, Louisville 3. Meets monthly, second Friday, at Seelbach Hotel, Louisville.

Louisiana

ORLEANS PARISH RADIOLOGICAL SOCIETY. *Secretary*, Joseph V. Schlosser, M.D., Charity Hospital of Louisiana, New Orleans 13. Meets second Tuesday of each month.

RADIOLOGICAL SOCIETY OF LOUISIANA. *Secretary-Treasurer*, Seymour Ochsner, M.D., Ochsner Clinic, New Orleans 15.

SHREVEPORT RADIOLOGICAL CLUB. *Secretary*, W. R. Harwell, M.D., 608 Travis St. Meets monthly September to May, third Wednesday.

Maine

MAINE RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Francis J. O'Connor, M.D., Augusta General Hospital, Augusta. Meets in June, October, December, and April.

Maryland

BALTIMORE CITY MEDICAL SOCIETY, RADIOLOGICAL SECTION. *Secretary-Treasurer*, James K. V. Willson, M.D., 1100 N. Charles St., Baltimore 1. Meets third Tuesday, September to May.

MARYLAND RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Nathan B. Hyman, M.D., 1805 Eutaw Place, Baltimore 17.

Michigan

DETROIT X-RAY AND RADIUM SOCIETY. *Secretary-Treasurer*, Joseph O. Reed, Jr., M.D., 3825 Brush, Detroit 1. Meets first Thursday, October to May, Wayne County Medical Society rooms.

UPPER PENINSULA RADIOLOGICAL SOCIETY. *Secretary*, Arthur Gonty, M.D., Menominee. Meets quarterly.

Minnesota

MINNESOTA RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Donald H. Peterson, M.D., 25 W. Fourth St., St. Paul 2. Meets Fall, Winter, and Spring.

Mississippi

MISSISSIPPI RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Robert P. Henderson, M.D., 316 Medical Arts Bldg., Jackson. Meets monthly, on third Thursday, 6:00 P.M., at Hotel Edwards, Jackson.

Missouri

GREATER ST. LOUIS RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Charles J. Cherre, M.D., 462 N. Taylor, St. Louis 8. Meets on fourth Wednesday, October to May.

RADIOLOGICAL SOCIETY OF GREATER KANSAS CITY. *Secretary-Treasurer*, Samuel B. Chapman, Jr., M.D., 830 Argyle Bldg., Kansas City, Mo. Meets last Friday of each month.

Montana

MONTANA RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Arthur T. Austin, M.D., 104 Doctors Bldg., Billings. Meets annually.

Nebraska

NEBRASKA RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Wayne K. Tice, M.D., 128 N. 13th St., Lincoln 8. Meets third Wednesday of each month at 6 P.M. in Omaha or Lincoln.

New England

CONNECTICUT VALLEY RADIOLOGIC SOCIETY. *Secretary-Treasurer*, Paul J. Kingston, M.D., 114 Woodland St., Hartford, Conn. Meets second Friday of October and April.

NEW ENGLAND ROENTGEN RAY SOCIETY. *Secretary*, John E. Gary, M.D., 1180 Beacon St., Brookline 46, Mass. Meets third Friday, October through May, Longwood Towers, Brookline, Mass.

New Hampshire

NEW HAMPSHIRE ROENTGEN RAY SOCIETY. *Secretary-Treasurer*, Paul Y. Hasserjian, M.D., 1470 Elm St., Manchester. Meets three times a year.

New Jersey

RADIOLOGICAL SOCIETY OF NEW JERSEY. *Secretary*, Andrew P. Dedick, Jr., M.D., 67 E. Front St., Red Bank. Annual meeting in May, Atlantic City; Fall meeting October or November, Newark.

New York

BROOKLYN RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, George A. Manfredonia, M.D., One Hanson Place, Brooklyn. Meets first Thursday of each month.

BUFFALO RADIOLOGICAL SOCIETY. *Secretary*, Alfred H. Dobrak, M.D., 108 Pine St., Buffalo. Meets second Monday, October to May.

CENTRAL NEW YORK ROENTGEN SOCIETY. *Secretary*, Joseph A. Head, M.D., University Hospital, 150 Marshall St., Syracuse. Meets second Monday, October through May.

KINGS COUNTY RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, C. P. Naidorf, M.D., 411 Parkside Ave., Brooklyn 26. Meets fourth Thursday, October to April (except December), at 9:00 P.M., Kings County Medical Bldg.

NASSAU RADIOLOGICAL SOCIETY. *Secretary*, Jerome Zwanger, M.D., 126 Hicksville Road, Massapequa. Meets second Tuesday, February, April, June, October, and December.

NEW YORK ROENTGEN SOCIETY. *Secretary*, Harold G. Jacobson, M.D., Montefiore Hospital, 210th St. and Bainbridge Ave., New York 67, N. Y.

NORTHEASTERN NEW YORK RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Irving Van Woert, Jr., M.D., Albany Hospital, Albany. Meets in the capital area second Wednesday, October, November, March, and April; annual meeting, May or June.

RADIOLOGICAL SOCIETY OF STATE OF NEW YORK. *Secretary-Treasurer*, Mario C. Gian, M.D., 610 Niagara St., Buffalo 1. Meets annually with the State Medical Society.

ROCHESTER ROENTGEN-RAY SOCIETY. *Secretary-Treasurer*, John W. Colgan, M.D., 277 Alexander St., Rochester 18. Meets at Strong Memorial Hospital, 8:15 P.M., last Monday of each month, September through May.

WESTCHESTER RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Arnold Myron Wald, M.D., 406 Boston Post Road, Port Chester. Meets third Tuesday of January and October and as announced.

North Carolina

RADIOLOGICAL SOCIETY OF NORTH CAROLINA. *Secretary-Treasurer*, Charles Bream, M.D., North Carolina Memorial Hospital, Chapel Hill, N.C. Meets in spring and fall of each year.

North Dakota

NORTH DAKOTA RADIOLOGICAL SOCIETY. *Secretary*, Marianne Wallis, M.D., Minot. Meets in the Spring with State Medical Association; in Fall or Winter on call.

Ohio

OHIO STATE RADIOLOGICAL SOCIETY. *Secretary*, Francis C. Curtzwiler, M.D., 421 Michigan St., Toledo. Next annual meeting, Cincinnati, May 1959.

CENTRAL OHIO RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Arthur R. Cohen, M.D., 41 S. Grant Ave., Columbus. Meets second Thursday, October, November, January, March, and May, 6:30 P.M., Fort Hayes Hotel, Columbus.

CLEVELAND RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Frederick A. Rose, M.D., 2065 Adelbert Road, Cleveland 6. Meets at 7:00 P.M., fourth Monday, October, November, January, February, March and April, at Tudor Arms Hotel.

GREATER CINCINNATI RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Warner A. Peck, Jr., M.D., 441 Vine St., Cincinnati 2. Meets first Monday, September through May, at Cincinnati General Hospital.

MIAMI VALLEY RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, G. F. Johnson, M.D., 1030 Reibold Bldg., Dayton 2, Ohio. Meets monthly, second Thursday, Miami Valley Hospital, Dayton.

Oklahoma

OKLAHOMA STATE RADIOLOGICAL SOCIETY. *Secretary*, Edmond H. Kalmon, Jr., M.D., 300 Northwest 12th St., Oklahoma City.

Oregon

OREGON RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, C. V. Allen, M.D., 9855 S.W. Hawthorne Lane, Portland. Meets monthly, second Wednesday, October to June, at 8:00 P.M., University Club, Portland.

Pacific Northwest

PACIFIC NORTHWEST RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, J. Arch Colbrunn, M.D., 1919 Royal Oak Drive, Roseburg, Ore. Meets annually, in May.

Pennsylvania

PENNSYLVANIA RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Walter P. Bitner, M.D., 234 State St., Harrisburg. Next annual meeting, April 24–25, 1959, Harrisburg.

PHILADELPHIA ROENTGEN RAY SOCIETY. *Secretary*, Roderick L. Tondreau, M.D., 3400 Spruce St., Philadelphia 4. Meets first Thursday of each month at 5:00 P.M., from October to May, in Thompson Hall, College of Physicians.

PITTSBURGH ROENTGEN SOCIETY. *Secretary*, Erwin Beck, M.D., 3500 Fifth Ave., Pittsburgh, 13. Meets monthly, second Wednesday, October through June, Park Schenley Restaurant.

Rocky Mountain States

ROCKY MOUNTAIN RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, John H. Freed, M.D., 4200 E. Ninth Ave., Denver 20, Colo. Next annual meeting, Aug. 20–22, 1959, Shirley-Savoy Hotel, Denver.

South Carolina

SOUTH CAROLINA RADIOLOGICAL SOCIETY. *Secretary*, Wayne Reeser, M.D., 1600 Ninth Ave., Conway. Meets with State Medical Association in May.

South Dakota

RADIOLOGICAL SOCIETY OF SOUTH DAKOTA. *Secretary-Treasurer*, Donald J. Peik, M.D., 303 S. Minnesota Ave., Sioux Falls. Meets during annual meeting of State Medical Society.

The Southeast

Southern Radiological Conference. *Secretary-Treasurer*, Marshall Eskridge, M.D., 1252 Springhill Ave., Mobile, Ala.

The Southwest

SOUTHWESTERN RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Gordon L. Black, M.D., 1501 Arizona Bldg., El Paso, Texas.

Tennessee

EAST TENNESSEE RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Charles W. Reavis, M.D., Baroness Erlanger Hospital, Chattanooga. Meets in September and January, and prior to State Medical Association meeting.

MEMPHIS ROENTGEN SOCIETY. *Secretary-Treasurer*, James L. Booth, M.D., 899 Madison Ave., Memphis 3. Meets monthly first Monday, John Gaston Hospital.

TENNESSEE RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, James J. Range, M.D., P. O. Box 324, Johnson City. Meets annually with State Medical Association in April.

Texas

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ROENTGEN DIAGNOSIS

THE HEAD AND NECK

Evaluation of Roentgen Contrast Agents Used in Cerebral Arteriography. I. A Simple Screening Method. G. Margolis, G. T. Tindall, R. L. Phillips, P. D. Kenan, and K. S. Grimson. **II. Application of a New Method.** G. T. Tindall, P. D. Kenan, R. L. Phillips, G. Margolis, and K. S. Grimson. J. Neurosurg. **15:** 30–36; 37–44, January 1958. (Duke University School of Medicine, Durham, N. C.)

Having previously studied contrast medium injuries to the spinal cord in dogs (Margolis, Tarazi, and Grimson: J. Neurosurg. **13:** 349, 1956. Abst. in Radiology **68:** 770, 1957), the authors evolved a method of testing contrast agents on this basis. Adult dogs were used and the substances were introduced through a catheter inserted into the femoral artery and passed up the abdominal aorta to the level of L-3. Injection at the rate of approximately 5 c.c. per second in the supine animal causes a retrograde filling above the catheter tip for a distance of 3 to 5 cm. Three indicators are used to measure the toxicity of the injected agents: (1) the immediate convulsive response; (2) the neurological deficit as manifest upon recovery from anesthesia and subsequent daily observation; (3) anatomical lesions found on section of the cord when the animal is sacrificed four to six days after the injection. Criteria for grading each of these indicators are given.

This suggested testing method is simple and has the advantage over direct cerebral injection in that the survival of the animal permits an extended period of observation. It is pointed out that "there is a close correspondence in structure and blood supply of the cord of the dog. . .and of man."

Several radiopaque contrast agents were studied by the method described. The correlation of the three criteria of injury was excellent in severe toxic reaction but less complete in lesser grades of injury.

Of the five agents used, Renografin and Hypaque were the least toxic. Urokon was the most toxic. Diodrast and Miokon were about equal in toxicity and intermediate in position between the other agents. Varying concentrations and doses based on weight of the animal were used and are well summarized in eight tables.

The first paper is illustrated by 3 figures, including 1 roentgenogram.

HOWARD J. BARNHARD, M.D.
University of Arkansas Medical Center

Cerebral Angiography in Head Injuries. Jean-Louis Léger, Claude Bertrand, and Maurice Dufresne. J. Canad. A. Radiologists **9:** 8–13, March 1958. (Hôpital Notre-Dame, Montreal, Canada)

The authors review 215 angiograms of patients with head injuries seen over an eight-year period. They have utilized angiography in an increasing number of acute cases and find it particularly valuable in the study of intracerebral hematomas. It also serves in preventing false lateralization of lesions in patients with ipsilateral pyramidal-tract signs.

Positive results were obtained in 108 patients, and there were 101 negative studies. Six examinations were considered failures, mostly in young children in the early years of the study. In 77 of the 215 patients, plain films revealed skull fractures; in 37 of these, arteriographic studies were negative, while 53 positive angiograms were obtained in patients whose plain films showed no evidence of skull fracture. In 8 out of 25 cases of epidural hemorrhage, there was no evidence of skull fracture on routine films.

Brief descriptions of the roentgen characteristics of chronic and acute subdural hematoma and epidural hematoma are presented. Cerebral angiography provides a characteristic picture of subdural hematoma. A chronic hematoma will present as a biconvex lens-shaped mass between the inner table of the skull and the peripheral arteries or the ascending cerebral veins, which cover the surface of the brain and are pushed away with it by the lesion. In an acute subdural hematoma the superficial vessels are also pushed inward, but the surface of the brain is parallel to the inner table, since the pressure of the blood clot is applied equally on all the various points of this surface. Only one picture is characteristic of an epidural hematoma, namely, displacement of the superior longitudinal sinus downward from the calvarium.

The authors strongly urge the performance of cerebral angiograms in patients with acute head injuries and feel that the risk is slight as compared to the valuable information obtained by the procedure.

Thirteen roentgenograms; 1 graph; 2 tables.

RICHARD H. GREENSPAN, M.D.
University of Minnesota

Cerebral Metastases from Primary Pulmonary Tumor. A. Paglicci and E. Marzano. Radiol. med., Milan **44:** 277–283, March 1958. (In Italian) (Istituto di Radiologia Medica dell'Università di Roma, Italy)

The records of 152 cases of primary "pulmonary" cancer seen between 1947 and 1957 were available for review: 10 (6.57 per cent) of them were considered to have cerebral metastases, proved by exploratory surgery in 3 instances and by autopsy in 5. Because metastatic deposits occur comparatively early in the course of bronchogenic cancer, cerebral symptoms often precede the pulmonary manifestations. Therefore, sudden appearance of a "central nervous system syndrome" in a middle-aged man (the authors' 10 cases were all in males) should arouse suspicion of cerebral metastasis. The type and degree of neuropsychiatric modifications (altered sensorium, personality changes, psychotic episodes of the confusional type, loss of memory, pareses, seizures, etc.) will depend on the number and location of the metastases. In this series the left hemisphere was chiefly involved, more often anteriorly than posteriorly.

Routine skull roentgenograms gave no diagnostic indication in any of these cases. Cerebral angiography and encephalography, when significant, demonstrate a space-occupying lesion, but otherwise do not afford signs characteristic for metastatic activity.

Treatment is only palliative (except in very rare cases when surgical excision of an isolated nodule may control the condition), the average survival time after proof of metastasis being four months to one year. Roentgen therapy is sometimes beneficial in alleviating symptoms.

E. R. N. GRIGG, M.D.
Cook County Hospital, Chicago

Unusual Dysostosis of the Cranial Vault. G. Lischi. Radiol. clin. **27:** 78–87, March 1958. (In Italian) (Istituto di Radiologia dell'Università di Pisa, Italy)

In 1953, a 49-year-old male suffered a head injury. At that time, roentgenograms of the skull revealed a linear fracture in the right parietal bone and, in addition, noticeable bone atrophy throughout the cranial vault. The patient stated that as long as he could remember he had been able to feel a depression when palpating the area of the fontanel. Lateral views of the skull showed a wavy pattern of the atrophic outer table, while the inner table was well preserved. No similar findings were observed in any of the close relatives who submitted to skull roentgenography. Follow-up in 1956 revealed no essential change; even the fracture line was still identifiable, which would indicate a defect in reossification, but subjectively the patient was asymptomatic. After presenting detailed differential diagnostic considerations, the author assumes that the condition was a developmental abnormality (dysostosis).

Two roentgenograms. E. R. N. GRIGG, M.D.
Cook County Hospital, Chicago

The Roentgenologic Diagnosis of the Foramen Jugulare. F. Vándor. Radiol. clin. **27:** 114–121, March 1958. (In German) (Röntgenklinik der Medizinischen Universität Budapest, Hungary)

To demonstrate the foramen jugulare, the author uses, and recommends, the technic described by Porcher, Porot, and Rossand (J. radiol. et électrol. **33:** 379, 1952). It is applicable in weak patients, because it is performed in supine recumbency, with the head slightly hyperextended, and at the same time rotated 25° on its sagittal axis, so that the chin points toward the side opposite the one under consideration. The strictly vertical roentgen beam is then centered over the mandibular angle of the side to be examined. The exposure data are similar to those for the mastoid. In the roentgenogram thus obtained (with adequate collimation), the foramen jugulare is seen projected over the mandibular ramus.

The procedure is especially recommended in the presence of tumors of the glomus, of the middle ear, and of the epipharynx, as well as in chordoma. With proper bone detail, one may evaluate the area for destructive bone lesions, and from their extent and location, an experienced observer may even offer an educated guess as to which cranial nerves may soon become affected by the malignant process.

Eleven roentgenograms; 3 photographs; 1 drawing.
E. R. N. GRIGG, M.D.
Cook County Hospital, Chicago

Investigation of Children with Speech Defect, with Particular Reference to Nasality. James Calnan. Brit. M. J. **1:** 737–740, March 29, 1958. (Nuffield Department of Plastic Surgery, University of Oxford, England)

The title of this article would never attract a radiologist, but the special plates that accompany the text clearly depict the use of radiology in the very important problem of speech defects. "One can indeed make a fairly complete palatopharyngeal analysis on a simple lateral radiograph or, if even more accurate information is required, on a cephalometric tracing."

The term nasality has been applied to a variety of conditions. The authors deal here with "nasal escape," such as occurs in cleft plate. The causes of this phenomenon are listed, as follows:

Causes of Nasal Escape During Speech

A. ANATOMICAL DEFECTS OF PARTS (Mechanics)
   Congenital: Cleft palate; submucous cleft; absence of part of soft palate or pillars of fauces.
   Acquired: Trauma—surgical, gunshot wounds; disease—syphilis, cancer.
B. DEFECTIVE MOTOR POWER (Dynamics)
   Neurological: Nuclear and peripheral
      Congenital: Nuclear hypoplasia
      Acquired: Trauma; disease—diphtheria, poliomyelitis
      Supranuclear: Congenital paresis; encephalitis; meningitis
      Cortical: Gross mental deficiency; hysteria
   Muscular: Congenital agenesia—unilateral, bilateral; scar tissue.
C. DISPROPORTION OF PALATE AND PHARYNX (Kinetics)
      Repaired cleft palate
      Congenital short palate
      Congenital large pharynx
      Adenoidectomy

Among the technics used in the assay of organic speech defects the author lists cineradiography. [Cineradiography is not essential, however, if one makes use of an image amplifier at the conventional nonimage amplifier levels of milliamperage and kilovoltage.—S. F. T.]

Three cases are reported, and the economic aspects of successful correction are stressed.

Seventeen roentgenograms; 3 photographs; 3 graphs; 3 tables. SYDNEY F. THOMAS, M.D.
Palo Alto, Calif.

THE CHEST

Bronchography: Summary of a World-Wide Survey. Report of Committee on Broncho-Esophagology (Arthur M. Olsen, M.D., Mayo Clinic, Chairman). Dis. of Chest **33:** 251–259, March 1958.

A survey was conducted by the Committee on Broncho-Esophagology of the American College of Chest Physicians, with regard to types of bronchographic media, technics, anesthesia, indications and contraindications, complications, and fatalities. Questionnaires were mailed to 60 physicians around the world, 20 of whom were radiologists, and replies from 57 were received.

On none of the technics of bronchography was there unanimous agreement. Several drugs are used for premedication. Local anesthesia is employed universally among adults, cocaine and pontocaine being the favorite agents. Most men prefer the catheter method for instilling the opaque medium, but transglottic and transtracheal methods are also used. Several contrast media are used, but Oily Dionosil is the favorite. The amount injected varies between 15 and 40 c.c. Spot-films are obtained by some. The majority fill one side and take postero-anterior, oblique, and lateral views, thereafter filling the other side. Others fill both sides before films are taken. Sixteen participants did not use fluoroscopic observation.

That bronchography is indicated in bronchiectasis was agreed upon by all. Indeterminate hemoptysis, bronchostenosis, bronchial tumors, and middle-lobe

syndrome were good indications in the opinion of the majority. Chronic cough, tuberculosis, and lung abscess were thought to be indications by smaller numbers. About 30 considered iodine sensitivity (history) and recent pneumonitis contraindications. Heart disease, asthma, emphysema, and active tuberculosis were also mentioned as excluding the procedure.

All participants considered complications to be rare. Some of the reactions reported are fever, allergic reactions, pneumonitis, parotitis, granulomas, pneumothorax, dissemination of active pulmonary tuberculosis, and atelectasis. Seventeen fatalities were reported, 8 after administration of local anesthesia and 9 after instillation of the contrast medium.

The participants also reported their experience with bronchography in children. The majority use general anesthesia for this group.

Eight tables.

J. S. ARAJ, M.D.
Toledo, Ohio

Recent Advances in Bronchography. John E. Rayl and Daniel E. Smith. Dis. of Chest **33:** 235–250, March 1958. (VA Hospital, Oteen, N. C.)

In reviewing the recent advances in bronchography, the authors consider first the media and technic and then the interpretation of the bronchographic findings. Foreign-body reactions in the lung are greater when there is a large amount of alveolar filling. For avoiding such reactions, the use of Visciodol (sulfanilamide powder and Lipiodol) is suggested. This is a relatively viscous medium and therefore permits outlining the bronchial tree with little tendency to enter the alveoli. In 500 bronchographic studies with this agent, two sulfanilamide allergic reactions were encountered, and these responded well to antihistamines. Satisfactory examination was obtained in 89 per cent of the patients.

A selective technic, with the Metras catheter, is used for re-examination of segments which did not fill on previous studies. Retention of opaque medium in the lung is decreased by the use of bronchodilator drugs and postural drainage.

The authors describe a method of injecting surgical specimens of the lungs with an opaque medium, which solidifies. Roentgenograms of specimens thus prepared are of help in correlating x-ray appearance and histologic findings.

The value of a twenty-four-hour study after bronchography is stressed. The changes in acute and chronic bronchitis are described. The commonest findings in chronic bronchitis are alternate areas of narrowing and dilatation, occasionally associated with diverticula along the bronchial wall, producing "feathering" or a sawtooth appearance.

Twenty-six roentgenograms; 7 photomicrographs.

J. S. ARAJ, M.D.
Toledo, Ohio

Selective Segmental Bronchography. André Mackay, Armand Trépanier, and Maurice R. Dufresne. J.A.M.A. **166:** 1155–1158, March 8, 1958. (A. M., 1560 Sherbrooke St. E., Montreal, Canada)

The authors have performed 335 bronchographic studies since August 1952, utilizing a selective filling technic. Following premedication and local anesthesia, an appropriate curved Metras catheter (Metras: Presse méd. **55:** 198, 1947) is guided into the desired segment with the aid of fluoroscopy. The bronchi of the diseased segments are then filled with contrast medium and spot-films are obtained in various positions. If one of the large bronchi is narrowed or stenosed, an attempt is made to pass the catheter beyond the obstruction in order to visualize both sides of the lesion. The remaining segments of the lung under investigation are then filled selectively and spot-films of each are obtained. The study is completed by obtaining 14 × 17-inch postero-anterior, lateral, and oblique radiographs.

Bronchography performed in this manner is considered more useful than the blind postural technic. The latter often results in partial filling or emptying of segments before radiographs are made.

Aqueous Dionosil proved to be the most satisfactory bronchographic medium and, in the authors' experience, caused no untoward reactions except slight temperature elevation in 5 per cent of the cases.

Ten roentgenograms; 1 photograph.

SAMUEL B. HAVESON, M.D.
University of California, S. F.

The Scatter Roentgenogram: Its Application to the Determination of Predilection of Primary Tuberculosis. Walter Lentino. J.A.M.A. **166:** 1472–1473, March 22, 1958. (60 Prospect Ave., Middletown, N. Y.)

This communication reintroduces the scatter roentgenogram as a method of statistical roentgen analysis. The scatter roentgenogram is defined as a normal radiograph of any portion of the body upon which data from study of x-rays of a large number of individuals are plotted. It is similar to the statistician's scattergram except that in place of ordinate and abscissa one utilizes the radiograph as the background upon which clinical data are plotted.

The scatter roentgenogram in the situation described here is a normal postero-anterior chest teleroentgenogram, on which information obtained from analysis of a large number of cases is projected. The data were obtained from 3,000 photoroentgenograms, studied in sequence, of healthy asymptomatic individuals. Whenever a solitary parenchymal calcification was noted, or a calcification in the parenchyma associated with a calcification at the homolateral hilus, the area of projection was noted upon a schematic drawing of the chest, and this point was subsequently charted on a composite roentgenogram.

Solitary calcifications are shown to be widely and indiscriminately distributed throughout both lung areas without selectively sparing or being concentrated in any segment. It is stated that the scatter roentgenogram has confirmed the clinical impression that primary (childhood) type pulmonary tuberculosis has no selective, localizing properties. The significance of this statement must be taken into the context of the observation that in New York State such calcifications are almost always the result of healed primary tuberculosis.

One roentgenogram.

THEODORE E. KEATS, M.D.
University of Missouri

Diagnostic Significance of Roentgenograms of the Thorax in Caudo-Cranial Suspension, Particularly in Staphylococcic Pneumonia of Infants. P. Krepler. Fortschr. a. d. Geb. d. Röntgenstrahlen **88:** 357–359, March 1958. (In German) (St.-Anna-Kinderspital in Wien, Austria)

With staphylococcic infections of the lungs in infants becoming more and more frequent, any technical x-ray

procedure that facilitates a differential diagnosis may be of great value. Difficulty is sometimes encountered in differentiating pleural opacities and in determining whether a cavity seen within these opacities is in the lungs or in the pleura. The author has found it helpful to obtain a film in caudo-cranial suspension in addition to the routine postero-anterior and lateral views. The infant is held by the feet, with the head hanging down. Through gravity, the exudate will travel toward the apex of the lung and the base becomes free. If there is a cavity filled with fluid and air, the caudal portion of the cavity (the bottom) becomes clearly visible because the air forms a good contrast medium. If there is a pyopneumothorax, the air will demonstrate the entire diaphragm, as well as the outline of the collapsed lower lung.

A case is reported in which this method facilitated the diagnosis and led to a cure of the disease.

Two roentgenograms.

WILLIAM A. MARSHALL, M.D.
Chicago, Ill.

Nontuberculous Pneumonia Complicating Pulmonary Tuberculosis. Salvatore A. LaBarbera, Harry H. Epstein, Lynn L. Fulkerson, and Arthur S. Granston. Ann. Int. Med. **48:** 635–646, March 1958. (S. A. L., U. S. Public Health Service Hospital, Staten Island, N. Y.)

Reports of the simultaneous occurrence of bacterial pneumonia and pulmonary tuberculosis are infrequent in the earlier literature. The first extensive investigation on this subject, by Baum and Amberson (Am. Rev. Tuberc. **45:** 243, 1942. Abst. in Radiology **39:** 365, 1942), led to the conclusion that pneumonia was not rare in tuberculous patients, the sheltered sanatorium life being held responsible in part for the low incidence previously reported. A follow-up study of 155 cases at the Bellevue Hospital by Baum and Baum (Am. Rev. Tuberc. **59:** 68, 1949) led these authors to believe that the apparent increase in coexistence of the two diseases was actually due to a greater awareness of the possibility.

The present paper is based on 47 cases of nontuberculous pneumonia associated with pulmonary tuberculosis. The authors were mainly concerned with the characteristics of the complicating pneumonia. Most of the cases did not represent the classic picture of lobar pneumonia. X-ray shadows were often patchy and the clinical course was frequently insidious. Chronic nontuberculous pulmonary infection may simulate tuberculosis and be easily missed when one is thinking in terms of spread or reactivation of a known tuberculosis. Frequent serial films and observations on the response to antibiotics without antituberculosis drugs may aid in the differentiation in inactive cases.

The present report showed absence of mortality from the complicating pneumonia and a low incidence of exacerbation of tuberculosis reasonably contrasting with the earlier series before the antituberculosis chemotherapy and antibiotic era. Nowadays, though the tuberculous process is better arrested by medication and surgery, the patient is left with a damaged bronchial system and limited pulmonary reserve, which make him more susceptible to development and prolongation of pneumonia. The authors stress the importance of a correct diagnosis.

Six tables.

CARL PONISCHIL, M.D.
Cleveland City Hospital

The Roentgen Changes in Pulmonary Moniliasis of Infants. K. Gefferth. Fortschr. a. d. Geb. d. Röntgenstrahlen **88:** 347–356, March 1958. (In German) (I. Univ.-Kinderklinik Budapest, Hungary)

Generalized moniliasis has become more frequent with the advent of the antibiotics, probably as a result of their action. In the lungs the condition may occur by itself or it may be superimposed upon a pre-existing disease.

The author presents in detail the records of 5 cases. One patient died and the diagnosis was confirmed postmortem. In the other 4, who were followed for a period of several years, the diagnosis was established by the demonstration of *Candida* in the blood, sputum, urine, or spinal fluid.

The clinical course varied. In the fatal case there was no fever at all. In the others moderate fever was observed at various intervals. The x-ray findings, although not pathognomonic, were quite helpful. They included a broadening of the hilar regions, "cloud-like" pulmonary markings, and many individual densities, mainly in the perihilar area, ranging in size from that of a pinpoint to a buckshot or slightly larger. These nodule-like densities may resemble miliary tuberculosis. The fungus seems to form a small granuloma which looks like a tubercle. It is characteristic that the x-ray findings in moniliasis are long lasting; the shortest duration was six or seven weeks. In one of the cases they were still observed after twenty-seven months. Eventually calcification occurs, as in tuberculosis. The findings on auscultation are rather meager and much less than one would expect from the x-ray appearance.

In conclusion, the author feels that the suspicion of moniliasis is justified if the above-mentioned x-ray findings are present in an infant that has been receiving antibiotics without improvement.

Seventeen roentgenograms.

WILLIAM A. MARSHALL, M.D.
Chicago, Ill.

Hemangiopericytoma of the Lung. Seymour Ochsner and Paul T. DeCamp. Am. Rev. Tuberc. **77:** 496–500, March 1958. (Ochsner Clinic, New Orleans, La.)

Hemangiopericytoma is a vascular tumor arising from the pericyte. This is a modified smooth muscle cell closely applied to the outer capillary wall which apparently alters the size of the capillary lumen. Most of these tumors appear to be benign but are potentially malignant. They have been reported in a variety of locations, including the colon, retroperitoneal space, and meninges. Only one such tumor arising in the lung has been reported previously (McCormack and Gallivan: Cancer **7:** 595, 1954).

The patient described in the present paper was a 38-year-old Negro male with a history of recurrent hemoptysis for thirteen years. Chest roentgenograms revealed a mass in the right medial lung base posteriorly, which was irregularly oval in contour and somewhat poorly defined. It measured 8 × 6 cm. and extended into the bronchial tree at the orifices of the medial and posterior basal segmental bronchi, where it was visualized bronchoscopically. After pneumonectomy, recovery was uneventful.

Two roentgenograms; 1 photomicrograph.

JOHN H. JUHL, M.D.
University of Wisconsin

Roentgenologic Aspects of Pneumatocele and of Its Evolution. Franco Chiariotti. Radiol. med., Milan **44:** 209–224, March 1958. (In Italian) (Reparto Radiologico dell'Ospedale di Busto Arsizio, Italy)

Having observed 11 cases of postpneumonic bullous emphysema in children (9 under five years of age) in the past two years, the author suggests that this condition might better be designated by the more generic term pneumatocele. The ballooning occurs as a result of bronchial valve action, explainable either on a mechanical basis or by incrimination of a "nervous" factor (bronchospasm as a result of neurovegetative disturbances). The cavity itself might conceivably represent inflation of an abscess subsequent to emptying by fistulization into a draining bronchus.

The pneumatocele may be single or multiple (unilateral or bilateral), central (perihilar) or peripheral (subpleural), diminishing or increasing in size. Its complications are giant bleb formation (occupying an entire hemithorax), abscess formation, pleural perforation (with or without empyema, but always with "spontaneous" pneumothorax), and mediastinal perforation (pneumomediastinum with or without subcutaneous emphysema). Roentgenologic identification is fairly easy, the differential diagnosis including congenital cysts, polycystic lung, acquired or postinfectious cysts, abscess, tuberculous cavity, diaphragmatic hernia, and pneumothorax. Body-section roentgenography is sometimes of help in the detection of blebs hidden behind thick infiltrates.

Areas of pneumonitis, atelectasis, and emphysema in the parenchyma surrounding the pneumatocele are of importance for its subsequent evolution, The regularity of its walls depends on the pressure inside the bleb: wavy walls speak for low tension, while a circular or oval shape indicates high intracavitary pressure. As far as prognosis is concerned, pneumatocele proceeds, as a rule, toward complete restoration (with disappearance of all roentgenologic findings), except when suppurative complications supervene.

Thirty-seven roentgenograms.

E. R. N. GRIGG, M.D.
Cook County Hospital, Chicago

Oil Granuloma of the Lung. Report of Three Cases. A. H. M. Siddons. Brit. M. J. **1:** 305–307, Feb. 8, 1958. (St. George's Hospital, London, England)

Oil granuloma of the lung, resulting from the inhalation of mineral, vegetable, or animal oils and fats, may produce masses clinically and radiologically indistinguishable from bronchial carcinoma.

These granulomas are reportedly more common at the extremes of life, occurring in babies with feeding problems and in the aged, in whom neurological and cerebrovascular disorders may be associated with disturbances of swallowing. The habitual use of mineral oil as a laxative and nasal sprays containing mineral oils may be causative factors. The condition has also been reported many times in association with achalasia of the esophagus or cardiospasm.

In the 3 cases reported here, bronchial carcinoma was the preoperative diagnosis, although bronchoscopy was negative in all instances. Radiologically, relatively large confluent masses were demonstrated, in one instance in the left lower lobe, in another in the right middle lobe, and in a third in the right upper and middle lobes. Bronchography is not reported and apparently was not done. Frozen section afforded the diagnosis in 2 cases, as otherwise, even at operation, carcinoma could not be excluded.

The patients were aged seventy-two, fifty-six, and forty-one years, respectively. One gave a long history of ingestion of mineral oil. Another had achalasia which had been treated surgically. In the remaining case the origin of the granuloma was unexplained.

Three roentgenograms; 1 photomicrograph.

JOHN F. RIESSER, M.D.
Springfield, Ohio

An Unusual Cause of Massive Hemothorax. Sydney Bassin and Farhan Bakir. Dis. of Chest **33:** 330–334, March 1958. (City Hospital, New York, N. Y.)

An unusual complication of strangulated diaphragmatic hernia is reported in a 33-year-old man. The patient was admitted because of shortness of breath, cough, left chest pain, abdominal swelling, and constipation. A chest film revealed massive left pleural effusion, which on thoracentesis proved to be grossly bloody fluid. Abdominal films showed distended small and large bowel loops, with fluid levels. A barium enema study was not done.

The true nature of the condition was recognized on autopsy. A loop of the splenic flexure and transverse colon was herniated through an opening in the posterolateral portion of the left diaphragm. The loop was edematous, hemorrhagic, and necrotic.

Five roentgenograms.

J. S. ARAJ, M.D.
Toledo, Ohio

The Asymptomatic Period in Retained Foreign Bodies of the Bronchus. George A. Miller, Cesare Gianturco, and Howard C. Neucks. J. Dis. Child. **95:** 282–283, March 1958. (602 W. University Ave., Urbana, Ill.)

On review of their last 15 cases of foreign body in the bronchus, the authors found that in 5 of these diagnosis and definitive care were delayed from three days to five months. On further study, each of the patients was found to have had a choking spell while eating, but the history of such an episode was sometimes elicited only with a great deal of persistence. There was a variable asymptomatic period, followed by symptoms and signs of acute or chronic lung disease. It is of interest that the chest films before delayed removal of the offending particle revealed only heavy markings or a nonspecific infiltrate in 4 of the 5 children; in 1 case a typical obstructive emphysema was demonstrated.

It is pointed out that if bronchial obstruction does not occur after aspiration, an asymptomatic interval may follow. This can last for months or years in the case of bone and inorganic matter. Vegetable matter, such as peanuts, tends to cause an inflammatory response in hours or days, the interval being roughly inversely related to age. Therefore, the possibility of a bronchial foreign body should always be considered in children with acute or chronic lung disease.

LAWRENCE A. POST, M.D.
University of California, S. F.

Mediastinal Tumors and Cysts in Children. George J. Richards, Jr., and Robert J. Reeves. J. Dis. Child. **95:** 284–291, March 1958. (Duke Hospital, Durham, N. C.)

Three case reports of primary mediastinal cysts in infants are presented, preceded by a brief anatomic de-

scription of the mediastinal compartments and a fairly complete listing of the various inflammatory and neoplastic masses which occur in these compartments. The 3 cases were seen within a period of two months. In the preceding twenty-five years only 14 cases of primary mediastinal cysts and tumors had been encountered in the pediatric age group (birth to fourteen years) at Duke Hospital (Durham, N. C.).

The first of the 3 cases was an enterogenous cyst which presented as a large homogeneous density occupying the posterior two-thirds of the right hemithorax in an asymptomatic girl of two months. The heart and mediastinum were displaced to the left and the barium-filled esophagus was deviated anteriorly and to the right. At surgery no demonstrable connection was discovered between the cyst and the esophagus.

The second patient, a boy of twenty-three months, with a history of frequent respiratory infections, had a mass located posterior to the heart and extending beyond the left cardiac border. The lower esophagus was displaced to the left and posteriorly. At surgery a dumbbell-shaped bronchial cyst was found.

The third report concerns a three-month-old boy with rapid respirations and coughing episodes from early infancy. A large cardiac shadow was noted on films at six weeks; there was no cyanosis or cardiac murmur. The electrocardiogram showed right axis deviation and suggested right ventricular hypertrophy. On fluoroscopy the pulsations along the right heart border were poor or absent. There was no roentgen evidence of a posterior mediastinal mass. An angiocardiogram demonstrated a distinct nonopaque impression on the right atrium, with displacement of the heart to the left and clockwise rotation on its axis. Operation disclosed a large intrapericardial teratoma, which mass was successfully removed. It is believed that this is the first example of this rare tumor to be demonstrated by angiocardiography.

Ten roentgenograms. LAWRENCE A. POST, M.D.
University of California, S. F.

Loculated Pleural Effusion in Congestive Heart Failure Due to Severe Anemia: Report of a Case. L. M. Sanghvi and S. N. Misra. Am. Heart J. **55:** 421–423, March 1958. (Department of Cardiology, Sawai Man Singh Hospital and Medical College, Jaipur, India)

A young woman with marked anemia secondary to malaria was admitted to the hospital in severe congestive failure. A roentgenogram of the chest showed enlargement of the cardiac shadow and evidence of a loculated effusion on the right side in the anterior inferior mediastinum. Paracentesis was performed, and the density disappeared. Three months later an artificial pneumothorax was induced, and roentgen examination clearly showed absence of any pleural adhesions.

Two cases have been reported previously which demonstrated that obliteration of the general pleural cavity by adhesions is not necessary for the presence of a loculated effusion in congestive heart failure (Feder and Wilk: Dis. of Chest **30:** 289, 1956. Abst. in Radiology **69:** 135, 1957; Laufer: Nova Scotia M. Bull. **25:** 229, 1946). In each of these cases effusion occurred in the general pleural cavity after disappearance of the loculated effusion.

Three roentgenograms.

ROGER M. STOLL, M.D.
New York, N. Y.

THE HEART AND BLOOD VESSELS

Cor Triatriatum. Paul W. Seavey and Edward R. Dorney. Am. Heart J. **55:** 272–276, February 1958. (Emory University School of Medicine. Atlanta, Ga.)

Cor triatriatum is a rare congenital condition in which a transverse septum divides the left atrium into two separate chambers. The upper chamber receives the blood from the pulmonary veins and communicates with the lower chamber through one or more small apertures. The condition simulates mitral stenosis. It can be corrected by surgery.

The authors present the case of a 5-year-old boy with evidence of cardiac decompensation since the age of one year. Roentgen examination of the chest showed the heart to be enlarged, with prominence of the right ventricle and right atrium. The primary and secondary pulmonary artery segments were prominent. The diagnosis was atypical patent ductus with pulmonary hypertension. At operation, however, a patent ductus was not demonstrated. No correctable defect could be found, and the chest was closed. The patient expired five hours postoperatively.

Postmortem the right atrium and ventricle were found to be enlarged. On opening the heart, a cylindrical cavity was discovered, separated from the auricular appendage and mitral valve by a fibrous membrane.

Angiocardiography has never been performed on any of these patients, but would probably show contrast medium retained in the left atrium, as in mitral stenosis. The point is made that patients who are operated upon for mitral stenosis and are found to have normal mitral valves at operation should then have complete exploration of the left atrium.

Two roentgenograms; 1 electrocardiogram.

ROGER M. STOLL, M.D.
New York, N. Y.

Tricuspid Valvular Insufficiency: Diagnosis by Cardiac Ventriculography—Right (Transthoracic Needle Puncture Opacification of the Right Ventricle). Benjamin G. Musser, J. Stauffer Lehman, Richard A. Gilman, and Randal A. Boyer. Ann. Surg. **147:** 339–346, March 1958. (The Hahnemann Medical College and Hospital, Philadelphia, Penna.)

The clinical evaluation of tricuspid insufficiency may be quite difficult. Physical examination, chest fluoroscopy, conventional film studies, electrocardiograms, and cardiac catheterization are of limited usefulness. Angiocardiography is unreliable; the regurgitant jet of right ventricular blood, producing a filling defect in the opacification of the right atrium during this procedure is not observed with regularity in tricuspid insufficiency.

The authors have found a procedure of direct opacification of the right ventricle and the demonstration of regurgitation of the radiopaque medium through the tricuspid valve into the right atrium an effective means of direct manifestation and possible quantitation of insufficiency of that valve. Fifteen patients between the ages of twenty-one and fifty-three years were studied by means of this procedure. Of 11 successful studies, 7 showed definite opacification of the right atrium. Correlation between the radiographic evidence of competence and clinical or anatomical evaluation was excellent.

To test the safety and reliability of the method, the authors injected the right ventricles of three anesthetized dogs under similar conditions. There was no evidence of regurgitation. Right ventricular pressures

taken during an injection of several times the amount of Diodrast used in the clinical case produced no evidence of evaluation of either systolic or diastolic pressure levels.

Fourteen roentgenograms.

ROBERT S. ORMOND, M.D.
Dearborn, Mich.

The Clinical and Physiologic Criteria for Surgical Correction of Mitral Insufficiency. Julio C. Davila and Robert P. Glover, with Gerardo Voci, P. Jumbala, Robert G. Trout, and A. Jane Fritz. J. Thoracic Surg. **35:** 206–229, February 1958. (The Clinical Laboratory at Presbyterian Hospital, Philadelphia, Penna.)

Circumferential suture of the mitral valve was used to correct mitral insufficiency in 43 patients with advanced disease; 17 of the 20 patients with intractable preoperative failure are dead, while of the 23 patients with chronic but not intractable failure only 7 had died. Evidence, including autopsy findings, showed that the mechanical defect was corrected in the vast majority of cases, but this correction was not of lasting benefit in cases where the myocardial contractility had been destroyed by overdilatation.

Proper selection of cases should lower operative mortality and eliminate late deaths, but current methods of study are inadequate to evaluate the state of the myocardium. Clinical improvement of failure under medical management and the operative appearance of the left ventricle, especially its firmness and strength of contraction, are currently the best guides to good postoperative prognosis. Large heart size on roentgen examination, pulmonary hypertension, and failure of left ventricular end-diastolic pressure to decrease following correction of insufficiency are correlated to some extent with poor operative results.

Nineteen roentgenograms; 14 graphs; 4 tables.

GARTH R. DREWRY, M.D.
Oakland, Calif.

Hypertrophic Osteoarthropathy in Association with Congenital Cyanotic Heart Disease: Report of Two Cases. Robert W. Trever. Ann. Int. Med. **48:** 660–668, March 1958. (Johns Hopkins Hospital, Baltimore 5, Md.)

The association of simple clubbing of the fingers and toes with congenital cyanotic heart disease is a well known phenomenon, while the association of congenital cyanotic heart disease and hypertropic osteoarthropathy is not so well recognized. The author presents 2 cases of congenital cyanotic heart disease with long standing clubbing and the characteristic findings of hypertrophic osteoarthropathy. A review of the American and British literature revealed only 2 well documented similar cases. In neither of the author's cases could any cause for the pulmonary osteoarthropathy other than the underlying congenital cyanotic heart disease be discovered.

The second patient experienced marked relief of symptoms following subcutaneous administration of atropine. In this connection the author refers to the work of Flavell (Lancet **1:** 260, 1956), who relieved the persistent pain of osteoarthropathy in cases of bronchogenic carcinoma by surgically severing the vagus nerve on the side of the affected lung. In another case, reported by Means and Brown (Am. Heart J. **34:** 262, 1947. Abst. in Radiology **50:** 851, 1948), the deformities of the hands and feet were less conspicuous following the establishment of an anastomosis between the right common carotid and the right pulmonary artery.

In a series of over 3,000 cases of congenital cyanotic heart disease seen at the Harriet Lane Home (Baltimore), only 3 examples of associated hypertrophic osteoarthropathy were encountered. In none of the reported cases have signs and symptoms of hypertrophic osteoarthropathy appeared before the age of eleven years.

Four roentgenograms; 1 photograph.

HARRY GAZELLE, M.D.
Cleveland City Hospital

The Aortic Arch Syndrome of Takayasu. Chris L. Mengis, William Dubilier, and Kevin G. Barry. Am. Heart J. **55:** 435–442, March 1958. (New York, N. Y.)

The aortic arch syndrome of Takayasu, known also as "pulseless disease," includes bilateral loss of pulsations in the radial arteries, absence of detectable blood pressure in the arms, ocular and cerebral ischemia with progressive formation of peripapillary arteriovenous anastomoses, and cataracts. There are visual disturbances and syncope, with signs of collateral circulation to the head and arms *via* the intercostals, internal mammaries, and long thoracic arteries.

A case is presented of a 35-year-old woman admitted to the hospital because of "blacking out." She was found to have no radial pulse on the left and only a slight pulse on the right side. Blood pressure was unobtainable in the left arm and was 40/50 mm. Hg in the right arm, but was normal in the lower extremities. A cataract was found on the left. Films of the chest showed notching of ribs on the right. Angiocardiography demonstrated an irregularity of the contour and narrowing of the lumen of the aortic arch and descending aorta. The proximal segments of the innominate, left carotid, and left subclavian arteries did not opacify. Large tortuous intercostal arteries were visualized, with reversal of the usual blood flow from these vessels through the internal mammaries, lateral thoracic, and other major vessels of the thoracic wall into the axillary and carotid arteries.

The syndrome appears to be due to a degenerative arteritis of the aortic arch and brachiocephalic trunks, with obliteration of the lumen of the latter by an organized thrombus. The process involves the aortic arch, ascending aorta, descending aorta, innominate artery subclavian arteries, and carotid arteries.

A collagenous disease similar to lupus erythematosus has been suggested as a possible etiologic factor. Various infectious, inflammatory, and degenerative processes have also been mentioned as a possible basis.

The authors feel that the most reasonable approach in therapy is through reconstructive vascular surgery.

Four roentgenograms; 1 drawing; 1 pulse tracing.

ROGER M. STOLL, M.D.
New York, N. Y.

Aortic Arch Syndrome. Fay Segal and A. Berezowski. Am. Heart J. **55:** 443–449, March 1958. (Baragwanath Hospital, Johannesburg, Union of South Africa)

Segal and Berezowski list syphilitic aortitis and arteritis among the causes of the aortic arch syndrome of Takayasu, though Mengis *et al.* (see preceding abstract) state particularly that Takayasu's syndrome should be grouped separately from the similar syndrome

due to syphilitic aortitis and to degenerative heart disease. A case is reported in a 49-year-old African woman with syphilitic arteritis. The stenosed and occluded vessels were demonstrated by aortography.

Three roentgenograms; 2 electrocardiograms; 1 phonocardiogram.

Roentgenologic Findings in Five Cases of Congenital Aneurysm of the Aortic Sinuses (Sinuses of Valsalva). H. Gösta Davidsen, Olaf Petersen, and Gregers Thomsen. Acta radiol. **49**: 205–217, March 1958. (Rigshospitalet, University of Copenhagen, Denmark)

Aortic sinus aneurysms are usually not diagnosed clinically unless they rupture into the heart. When this occurs, the clinical picture is quite characteristic, with acute substernal chest pain, cough, dyspnea, and signs of acute heart failure.

Radiographic heart examination by conventional methods is usually not diagnostic. The heart may often appear normal, due to the intracardiac situation of the lesion and its small size. If, however, aneurysm of the aortic sinuses is suspected, special diagnostic studies may be performed. Cardiac catheterization will reveal the presence and size of a left-to-right shunt and the point at which the rupture has extended into the right heart. Thoracic aortography may show the anatomic relations of the aneurysm and may demonstrate the communication. Angiocardiography may help to determine the size of the heart chambers and the degree of hypertrophy of the ventricular walls. Electrocardiography may also be helpful, especially in conjunction with the radiographic findings.

Four cases of aortic sinus aneurysm are described, with their roentgenologic features. In the first, serial chest films showed progressive increase in heart size, catheterization revealed a shunt into the right atrium, and aortography demonstrated enlargement of a right aortic sinus.

In the second, chest films showed bilateral heart enlargement, which was progressive; angiocardiography disclosed dilatation of the right auricle and ventricle, and aortography showed marked dilatation of the right anterior sinus.

In the third, moderate left heart enlargement was apparent on the plain film and aortography revealed a dilated right coronary sinus with regurgitation of contrast medium into the left ventricle.

In the fourth case, the heart was seen to be enlarged to the left on the chest film; angiocardiography demonstrated marked hypertrophy and dilatation of the left ventricle, and aortography showed dilated left coronary and posterior (noncoronary) sinuses.

A fifth case is mentioned in which the aortic sinus aneurysm had not ruptured and heart size and shape were normal.

Ten roentgenograms. DON E. MATTHIESEN, M.D.
Phoenix, Ariz.

Infradiaphragmatic Total Anomalous Pulmonary Venous Connection. Arnold L. Johnson, F. W. Wigglesworth, J. S. Dunbar, Sarjit Siddoo, and Maria Grajo. Circulation **17**: 340–347, March 1958. (Montreal Children's Hospital, Montreal, Quebec)

Uncomplicated total anomalous pulmonary venous drainage in which the common pulmonary vein connects with the systemic circulation beneath the diaphragm is a rare anomaly. Four such cases are reported. The sites of entry to the systemic circulation were the ductus venosus, main portal vein, left portal vein, and the "region of the porta hepatis."

The lung fields afford the clue to the diagnosis, presenting a reticular appearance due to minute scattered irregular densities. The heart shadow in the authors' cases was normal. The children were dyspneic and cyanotic. All died before reaching the age of twenty-four days.

A similar roentgen picture may be seen in hyaline membrane disease, amniotic fluid aspiration, atelectasis, and pulmonary hemorrhage, but as a rule the pattern is finer in these conditions; in pneumonia it is coarser. Angiography in the one case in which it was done confirmed the diagnosis.

The anomaly can be tolerated for only a few days because the common pulmonary vein narrows before entering the systemic circulation, producing obstruction to the flow of blood; because all the blood must be handled by the right heart; because there is a right-to-left shunt through the foramen ovale.

No patient has been operated upon, but the authors believe that surgery might be possible if diagnosis were made in time, since the mobility, diameter, and length of the common pulmonary vein would allow for an anastomosis to the left atrium, which in the cases reported here appeared to be of adequate size to accept the pulmonary venous return.

Nine figures, including 4 roentgenograms; 2 tables.
ZAC F. ENDRESS, M.D.
Pontiac, Mich.

Bronchial Obstruction Due to Pulmonary Artery Anomalies. I. Vascular Sling. II. Pulmonary Artery Aneurysm. Stephen Contro, Robert A. Miller, Harvey White, and Willis J. Potts. Circulation **17**: 418–423; 424–427, March 1958. (Children's Memorial Hospital, Chicago, Ill.)

I. Three cases are reported in which the left pulmonary artery formed a "vascular sling," compressing the trachea and right bronchus. Five similar cases were found in the literature. In all, the right branch coursed normally but the left crossed the midline anteriorly, passing over the right bronchus and back to the left side between the esophagus and trachea.

Radiographically the cardiovascular silhouette was normal. Bronchography in one case showed external pressure on the right main stem bronchus and lower trachea. [No mention is made of the use of angiocardiography, although this should surely make the diagnosis.—Z. F. E.] Clinically the patients were dyspneic and cyanotic, with wheezing and sternal retraction.

In 2 of the 3 cases surgery was performed to correct the condition but was successful in only 1; in the other the left side of the chest was opened and the cause of the compression was not realized. In the third case the diagnosis was made at autopsy. The authors emphasize that the right side must be explored when the anomaly is suspected.

Five roentgenograms; 1 photograph; 2 drawings.

II. Two cases of bronchial obstruction were found in which aneurysmal dilatation of the pulmonary artery compressed the left bronchus, leading to left pulmonary emphysema and displacement of the mediastinum to the right. Both cases were diagnosed by angiocardiography. Surgery was attempted in one (pneumonectomy) but the patient died.

Five roentgenograms. ZAC F. ENDRESS, M.D.
Pontiac, Mich.

Coronary Arteriovenous Fistula. Israel Steinberg, Janet S. Baldwin, and Charles T. Dotter. Circulation **17:** 372–390, March 1958. (I. S., New York Hospital-Cornell Medical Center, New York, N. Y.)

Coronary arteriovenous fistulas arise from either persistence of primitive communications between the right heart chambers and the coronary arteries or from development of collateral channels between a normally originating coronary and one taking its origin from the pulmonary artery. In the latter instance the pressure difference causes a reversal of flow toward the pulmonary artery.

Roentgenographically, plain films may be entirely negative or an aneurysmal sac may be seen in profile. Calcification may occur and there may be cardiac enlargement. The volume of the shunt and therefore the significance of the lesion and its effect on the heart vary considerably. Angiocardiography or direct coronary arteriography will confirm the diagnosis, usually suspected because of a peculiar murmur.

An extensive review of the literature is given, 21 published cases are presented at some length, and a new case is reported. The patient was six years old when first seen and had been observed for seven years without any evidence of disability. Her plain films were negative but angiocardiography showed the cirsoid cluster of vessels on the heart surface.

Two roentgenograms; 1 stethogram; 1 table.

ZAC F. ENDRESS, M.D.
Pontiac, Mich.

High-Speed Biplane Selective Angiocardiography. Lawrence A. Davis, Leonard Leight, and Everett L. Pirkey. J. Dis. Child. **95:** 292–299, March 1958. (226 E. Chestnut St., Louisville 2, Ky.)

The advantages of selective angiocardiography with a high-speed biplane changer are reiterated by the authors. Studies illustrating various congenital lesions of the heart and great vessels are presented, but there is no mention of the total experience or rate of diagnostic failure.

An Elema biplane apparatus is used, with exposure of six or twelve films per second. The proper placement of the catheter is controlled by both pressure curves and visual examination. In very young patients the catheter can often be placed in the left heart by way of the inferior vena cava and foramen ovale. General anesthesia is used for all studies, and the role of the anesthesiologist is stressed. Double injections are never given. Special injectors effectively eliminate air bubbles in the apparatus.

Of interest is the conclusion that in tetralogy of Fallot the aorta fills normally from the left ventricle; its early visualization is due to passage of medium through the ventricular septal defect, and therefore "overriding" is probably only projectional. On two occasions left-to-right shunts were demonstrated when blood oxygen studies were normal.

Twenty-one roentgenograms.

LAWRENCE A. POST, M.D.
University of California, S. F.

Paraplegia After Translumbar Aortography. Laurence A. Grossman and James A. Kirtley. J. A. M. A. **166:** 1035–1037, March 1, 1958. (L. A. G., 1816 Hayes St., Nashville 3, Tenn.)

The authors report the case of a 50-year-old man in whom paraplegia developed following translumbar aortography. He had a long history of severe hypertension and had previously undergone bilateral thoracolumbar sympathectomy (1949) and a left nephrectomy (1954) for a chronically infected and contracted kidney. In 1956, the patient was seen with symptoms and signs of distal aortic occlusion. Translumbar aortography was performed with two needles, with 70 per cent Urokon as the contrast medium. A test dose of 1 ml. was directly injected into the aorta and no sensitivity reactions were observed.

The first attempt at aortography failed, due to jamming of the cassette changer, and the injection was discontinued after the introduction of 12 c.c. Retrograde aortic filling and slight extra-aortic extravasation were noted. Fifteen minutes later, a second attempt was made, after replacing the needle at a lower level. Twenty cubic centimeters was injected, 10 c.c. through each needle. This study revealed conclusive evidence of aortic occlusion below the level of the third lumbar vertebrae. Two hours later, flaccid paralysis of the lower extremities and anesthesia below the T-11 dermatome were evident. The neurological defects were present without change four months later, when this report was submitted for publication.

Five other instances of this complication were found in a review of the medical literature, and a sixth case was discovered in the legal literature. The exact cause of the paraplegia is unexplained. Thrombosis of the spinal arteries has not been demonstrated at autopsy. It has been suggested that spinal cord damage may be produced by the direct toxic action of highly concentrated contrast material (Hol and Skjerven: Acta radiol. **42:** 276, 1954. Abst. in Radiology **65:** 299, 1955). In 3 cases, including the authors', prompt repeat injections were made after unsatisfactory initial attempts.

The authors abandoned aortography, indirect and direct, following this experience.

SAMUEL B. HAVESON, M.D.
University of California, S. F.

Arteriography as an Aid in the Diagnosis and Localization of Acute Arterial Injuries. Murray B. Lumpkin, William D. Logan, Cecil M. Couves, and John M. Howard. Ann. Surg. **147:** 353–358, March 1958. (Emory University School of Medicine and Grady Memorial Hospital, Atlanta, Ga.)

The authors believe that arteriography as an aid in localizing and evaluating the extent of acute injury to peripheral vascular structures has been neglected. This article reports a study of 22 patients with injuries to the lower extremities. Arteriography was performed in the operating room with the extremity prepared and draped for operation.

In 10 patients normal arteriograms were obtained. In half of these the wounds were explored and the arteriographic findings confirmed. Twelve other patients had positive findings on the arteriograms. Most types of vascular trauma were encountered, and a definite correlation between the existing defects and the radiographic observations was made in each instance, either on exploration or upon dissection of an amputated limb following blunt trauma. In case of complete block of an artery the exact localization of the block is not possible because of retrograde stagnation of blood.

Percutaneous arteriography utilizing local anesthesia is simple, rapid, and safe. Neither temporary nor permanent impairment of vascular function was encountered as a result of the procedure. The greatest con-

tribution of the technic is in avoiding unnecessary operations on the poor-risk patient who suffers from other more serious injuries.

Nine roentgenograms; 2 tables.

ROBERT S. ORMOND, M.D.
Dearborn, Mich.

Venography in the Diagnosis of Pelvic Tumours. Osborne Bartley. Acta radiol. **49:** 169–186, March 1958. (Sahlgrenska Sjukhuset, Gothenburg, Sweden)

Outlining the pelvic veins with contrast medium is offered as a diagnostic help in studying expanding lesions in the pelvis. Several brief case reports are presented.

After local anesthesia and bilateral percutaneous puncture of the femoral vein in the groins, polyethylene catheters are introduced into the external iliac veins. About 20 ml. of 20 per cent contrast medium (of the 3-iodized water-soluble type) is rapidly injected simultaneously into both catheters. The examination is carried out in two stages, first without and then with compression of the distal part of the inferior vena cava. Compression is applied by means of the same apparatus as that used for urography, with the rubber balloon against the lower part of the abdomen at the level of the iliac crests and somewhat to the right of the midline.

In 39 cases of suspected pelvic tumors, 44 examinations were carried out; and the radiographic findings were correlated as closely as possible with the operative findings. Abnormalities observed in the presence of pelvic tumors were: displacement, indentation, incomplete filling of veins, presence of dilated veins, contrast filling of anastomoses, and slow drainage of veins. Some of these changes may be found in other conditions such as thrombosis and periphlebitis. Normal indentations may be caused by the sacral promontory, by various adjacent arteries, and by compression of the left common iliac vein between the vertebral column and the aortic bifurcation. Contrast filling of anastomoses may occur with any increase in venous pressure, as with cardiac insufficiency or occlusion in the inferior vena cava.

Detailed knowledge of the normal anatomic variations of veins is essential, and displacement of small veins is difficult to estimate.

Pelvic venography has little value in determining whether a lesion is benign or malignant. When an expanding lesion is situated close to the ureter, ureterostenosis may occur; even a small malignant tumor or metastases may cause a stricture of the ureter by infiltration. A benign tumor, on the other hand, may cause displacement of the ureter, but no stenosis unless the mass is large enough to produce compression. The procedure carries a certain risk of thrombosis, although in this series no complications were encountered which could definitely be related to the examination.

Nineteen roentgenograms; 4 photographs; 1 drawing; 1 table.

DON E. MATTHIESEN, M.D.
Phoenix, Ariz.

THE DIGESTIVE SYSTEM

Gastric Volvulus: A Case Report of Organo-Axial Volvulus with Recovery. Francis P. King and William H. Bell, Jr. Ann. Int. Med. **48:** 676–685, March 1958. (F. P. K., 509 Middle St., New Bern, N. C.)

The authors report a case of acute organo-axial gastric volvulus in a 75-year-old female with coexisting diabetes mellitus, aortic stenosis, and hiatus hernia. At operation, the stomach was found to be twisted on itself so that the greater curvature lay in the region of the lesser sac. The cardia was incarcerated in the hernia.

Gastric volvulus may be organo-axial, when the stomach rotates around its long axis in the coronal plane, or mesentero-axial when it rotates from right to left or left to right in the sagittal plane. It may be total or partial, depending on whether the whole or a segment of the stomach rotates. It may be anterior or posterior, acute or chronic.

In either type of volvulus there is some elongation or other abnormality of the mesenteric attachments of the stomach, as a predisposing factor. Diaphragmatic hernia, as well as eventration of the diaphragm, is undoubtedly a predisposing factor in the lengthening of the mesenteries and explains the relatively frequent association of volvulus and diaphragmatic hernia.

The symptoms are extremely variable. In a typical acute complete volvulus, there is sudden epigastric pain, followed by vomiting which soon turns into an unproductive retching. Shock and abdominal distention occur. The triad of circumscribed epigastric pain, strong efforts to vomit without results, and inability to accept a stomach tube is said to be diagnostic. In chronic incomplete cases, the symptoms may be vague, consisting of indigestion, a sense of fullness, and slight pain in the epigastrium or in the lower chest.

The diagnosis is best made roentgenographically by an upper gastrointestinal series in conjunction with the clinical picture.

The treatment in the acute completely obstructed gastric volvulus is surgical. The subacute or chronic cases may respond to more conservative measures. However, if the torsion is 180° or more, the blood supply to the stomach is in jeopardy, recurrence is likely, and surgery will probably become necessary.

Five roentgenograms.

HARRY GAZELLE, M.D.
Cleveland City Hospital

Endometriosis of the Small and Large Intestine. Russell S. Boles and Philip J. Hodes. Gastroenterology **34:** 367–380, March 1958. (R. S. B., Rittenhouse Plaza, Philadelphia 3, Penna.)

Several of the more recent and more important publications on endometriosis are reviewed in moderate detail. Theories to explain the development of the condition and its clinical features are discussed. Most cases occur in the twenty- to forty-year age group but occasionally the chronic form will develop in women well past their menstrual life. Data from various series indicate that, of all patients with pelvic endometriosis, somewhere between 10 and 25 per cent will show involvement of the small or large intestine. In younger women the condition may closely mimic acute appendicitis or acute pelvic inflammatory disease and occasionally will result in acute intestinal obstruction. In older patients, in its more chronic form, it may closely resemble carcinoma of the distal colon or diverticulitis. It may simulate segmental enteritis in either age group. Endometriosis of the colon or rectum "should always be suspected in any female patient who may have suffered from menstrual irregularities and who presents evidence of endometriosis on pelvic examination and a history of long standing bowel symptoms which suggest obstruction, but who has suffered no weight loss, has had no rectal bleeding and relates her symptoms to menstruation."

Roentgen manifestations of endometriosis involving the intestinal tract are not pathognomonic or even highly characteristic. Since the ectopic endometrial nodules usually involve the serosa and muscle wall of the bowel, but seldom invade the mucosa, rectal bleeding is not a symptom. Barium enema studies with or without double contrast technics will tend to demonstrate nodular or irregular extrinsic pressure defects at the involved sites with varying degrees of stenosis. Adhesions, with fixation of involved bowel segments, are common. Mucosal changes are not seen. The most frequently involved segments of bowel are the rectosigmoid and the terminal ileum, but almost any site may be affected. Differentiation must be made from inflammatory or neoplastic lesions.

The authors report briefly 12 cases which they personally studied to illustrate the above points. One case was of additional interest in that there was disordered motor function of the small intestine due to peritoneal irritation, resulting from free endometrial fluid in the peritoneal cavity from pelvic endometriosis. Treatment is briefly discussed: it may be surgical, expectant, hormonal, or (rarely) irradiation.

Three roentgenograms; 2 photomicrographs; 1 photograph.

JAMES W. BARBER, M.D.
Cheyenne, Wyo.

Intermittent Gallstone Ileus of Six Years' Duration. Lee S. Monroe and John H. Kennedy. Gastroenterology **34:** 502–508, March 1958. (L. S. M., Scripps Clinic and Research Foundation, 476 Prospect St., La Jolla, Calif.)

A 71-year-old female was first seen in July 1956 for severe cramping abdominal pain with nausea and vomiting. She had had similar repeated attacks over a period of six years. In 1951 a cholecystectomy had been performed, with removal of a single large calculus. It was noted then that the gallbladder was firmly adherent to the duodenum.

Diagnostic studies in 1956 showed clustered stones in the pelvis and a mechanical small bowel obstruction. During the preoperative study period it was noted that the stones moved widely throughout the abdomen and did not maintain any particular relationship to the distended small bowel loops in the pelvis. At surgery there were found impacted in the ileum five gallstones ranging up to 1.5 cm. in diameter, caught proximal to a stenosed, fibrotic segment of bowel. The stones were removed and 14 cm. of ileum resected, resulting in complete cure.

It is speculated that a fistula developed between the gallbladder and the duodenum at the time of the initial symptoms in 1951, with discharge of several stones into the small bowel. The case is considered of interest because of the long-term intermittent small bowel obstruction, the apparent mechanical trauma with scarring from stones in the distal ileum, and the widely changing positions of the offending calculi.

Three roentgenograms; 2 photographs.

JAMES W. BARBER, M.D.
Cheyenne, Wyo.

Study of Colon by Use of High-Kilovoltage Spot-Compression Technique. Steven J. Figiel, Leo S. Figiel, and Desmond K. Rush. J.A.M.A. **166:** 1269–1275, March 15, 1958. (S. J. F., 4160 John R St., Detroit 1, Mich.)

In a series of approximately 100 proved cases of polypoid lesions of the colon, the authors evaluated the use of spot-compression studies at the time of fluoroscopy, high-kilovoltage enema films, post-evacuation roentgenograms, and double-contrast examinations in detecting small colonic polyps. Preparatory measures included a liquid nonresidue diet for twenty-four hours, 2 ounces of castor oil at 6 P.M. on the day before the examination, and cleansing enemas on the evening and morning before the examination. Sigmoidoscopy immediately preceding the examination was avoided.

A round cone measuring 6.5 inches in diameter and 2.5 inches in depth was used, mounted on a sturdy fluoroscopic screen. The screen was manually pressed onto the abdomen, even over the lower ribs, to flatten the colon after each segment had been optimally exposed and filled with barium. Spot-films of all flexures and any abnormal appearing segment were obtained in addition to anteroposterior and oblique projections of the filled colon, and a post-evacuation film. All exposures were made with a constant kilovoltage of 120 kv, a constant milliamperage of 200, and varying exposure times. I-X barium preparation was the preferred medium.

It is concluded that the combined use of large-field compression spot-films and high kilovoltage, following fluoroscopy, is superior to double-contrast studies in the detection of polyps. Lesions as small as 2 mm. in diameter were discovered in some cases by the former method, and multiple lesions were commonly encountered. Double-contrast examinations, on the other hand, occasionally failed to localize lesions as large as 2.5 cm. in diameter even when the observer knew exactly where to look for them.

The authors feel that in the older asymptomatic patient periodic observation of polyps measuring 5 to 7 mm. in diameter or less is safe. The incidence of malignant change in polyps not exceeding 5 mm. in diameter is less than 0.2 per cent (Arminski and McLean: Grace Hospital Bull. **33:** 57, 1955).

Six roentgenograms; 1 table.

SAMUEL B. HAVESON, M.D.
University of California, S. F.

Acute Inflammation of the Pancreas. H. L. Bockus. Gastroenterology **34:** 467–475, March 1958. (250 S. 18th St., Philadelphia, Penna.)

The author describes the clinical, laboratory, and therapeutic features of acute pancreatitis. Many of his data are drawn from his experience with a series of 94 attacks of acute pancreatitis occurring in 78 patients previously reported elsewhere (Bockus *et al:* Arch. Int. Med. **96:** 308, 1955). Some points of interest for radiologists are brought out. There is an occasional instance of nonvisualization of a normal gallbladder by cholecystographic methods occurring at times shortly after an episode of acute pancreatitis. This is presumably explained on the basis of temporary inhibition of liver function. Consequently it is advisable to postpone cholecystography for two weeks after any recognized attack of acute pancreatitis. In approximately one-third of the patients abnormal physical findings will develop at the lung bases, suggesting the presence of fluid, pleurisy, or pneumonitis. Plain films of the abdomen are not pathognomonic but will frequently be of help in demonstrating localized collections of small bowel gas in the region of the pancreas, indicative of localized reflex

ileus. Air filling and/or deformity of the duodenal loop may occasionally be observed. Calcification in the biliary tract or in the area of the pancreas may be helpful but is not frequently observable. Barium meal studies are not likely to be diagnostic, although in a few instances one may be able to demonstrate the presence of a pancreatic mass or extrinsic pressure defects on the stomach, duodenum, or duodenojejunal angle.

One table. JAMES W. BARBER, M.D.
Cheyenne, Wyo.

Cholegraphy with Depression of the Renal Excretion of the Contrast Medium. N. P. G. Edling and C. G. Helander. Acta radiol. **49:** 187–192, March 1958. (Karolinska Sjukhuset, Stockholm, Sweden)

In intravenous cholegraphy the contrast medium (Biligrafin) is excreted through both the liver and the kidneys. At times superimposition of the shadows of the right kidney pelvis and of the common duct leads to confusion and difficulty in appraisal of the biliary duct system.

Renal excretion of the medium can be depressed by concurrent intravenous administration of paraminohippuric acid (PAH). Penicillin also is eliminated *via* the kidney tubules and depresses simultaneous excretion of an iodine compound. If penicillin is given intramuscularly, combined with N,N′-dibenzylethylendiamine (Penditan), which is absorbed very slowly, the depressant effect lasts up to twenty-four hours. Intramuscular injection on the evening before examination is therefore effective.

These substances were used in conjunction with intravenous cholegraphy in 136 patients, and in 92 others cholegraphy was performed without using them. It was found that administration of PAH or Penditan produced higher common duct density with lower density in the renal pelvis than was observed in the control patients. If both PAH and Penditan were given in a combined injection, the depression of renal excretion was more profound than with either alone. No complications were encountered.

It is stated that Probenecid (p-/dipropylsulfamyl/-benzoic acid) added to benzyl penicillin also greatly reduces tubular excretion and may be given instead of Penditan for the same purpose.

Seven roentgenograms; 1 table.

DON E. MATTHIESEN, M.D.
Phoenix, Ariz.

Biliary Dyskinesia in T-Tube Cholangiography. Joseph Hodge, Claude Barrick, and Edward McLaughlin. Arch. Surg. **76:** 361–364, March 1958. (Jefferson Medical College Hospital, Philadelphia, Penna.)

To the known etiologic factors, accounting for symptoms persisting after cholecystectomy, the authors add another cause, namely, Medopaque-H (sodium *o*-iodohippurate), which has been used for T-tube cholangiography. Of 36 patients who had T-tube cholangiography with Medopaque-H, 10 exhibited severe reactions, namely, colicky abdominal pain and symptoms mimicking an acute pancreatitis or biliary lesion, immediately following injection of the contrast medium. When the study was repeated with the same agent, similar reactions again developed. Seven of the 10 cases are reported in detail. In 5 there was evidence of pancreatitis. J. S. ARAJ, M.D.
Toledo, Ohio

THE MUSCULOSKELETAL SYSTEM

Dysplasia Epiphysialis Hemimelica. Harold Fulton. J. Dis. Child. **95:** 276–281, March 1958. (10 Peterboro St., Detroit 1, Mich.)

Three cases of dysplasia epiphysialis hemimelica are added to the 31 in the literature. According to Fairbank (J. Bone & Joint Surg. **38B:** 237, 1956. Abst. in Radiology **67:** 910, 1956) only three conditions are known in which the primary defect lies in the epiphysis: dysplasia epiphysialis multiplex, stippled epiphyses, and dysplasia epiphysialis hemimelica. He coined the latter term for a condition which characteristically affects only the medial or lateral aspects of the epiphyses of a single limb, almost always a lower limb. Usually the knee and ankle are both affected, the most common sites being the distal femoral epiphysis and the talus; tarso-epiphyseal aclasis is a term which has been used to denote involvement of the ankle alone.

The clinical picture is one of an otherwise healthy child who complains of increased swelling over the inner or outer aspect of the knee or ankle. A varus or valgus deformity gradually appears and often a bony hard mass can be palpated on one aspect of the abnormal joint or joints. The affected limb may be longer than its mate.

At the onset of symptoms there may be no roentgen changes despite clinical deformity of the joint. Later a mass of separate ossification centers appears within the cartilage of the epiphysis. These centers gradually fuse with each other, producing irregular enlargement of the medial or lateral side of the epiphysis, with a smooth or lobulated bony projection into the joint space. The histologic features cannot be distinguished from osteochondroma. The diagnosis, therefore, is made on the basis of involvement along one aspect of a single limb. Proper treatment consists of corrective surgery at an early stage, before the affected joint becomes severely deformed.

Ten roentgenograms; 1 photomicrograph; 1 photograph. LAWRENCE A. POST, M.D.
University of California, S. F.

Displacements and Torsion of the Spine: Their X-Ray Symptoms and Their Evaluation as Causes of Radicular Diseases of Vertebral Origin. F. Sommer and K. Reinhardt. Fortschr. a. d. Geb. d. Röntgenstrahlen **88:** 301–308, March 1958. (In German) (Strahleninstitut der Universität Homburg/Saar)

We are accepting more and more some of the thoughts of chiropractors and osteopaths, who attribute most diseases to pathological pressure of bones upon nerves and vessels. The causal connection between sciatica and pressure upon the nerve roots in the lower back, as well as that between the shoulder-arm syndrome and pressure upon nerves in the lower cervical spine have been generally accepted. The authors feel, however, that they must reject the dictum that most human ailments are caused by rotational displacement of individual vertebrae and that this condition can be diagnosed by palpating the spinous processes. A rotational displacement of certain sections of the lumbar spine does sometimes occur. It is recognizable by a step in the lateral alignment of the vertebral bodies as seen on the x-ray film, but it is seldom associated with a displacement of the spinous processes, since the vertical axis around which the rotation takes place is far backward and may be in the very tip of the spinous processes.

In the authors' series only 15 per cent of the cases of rotational displacement were associated with a deviation of the spinous processes; most of the roentgenologically recognizable deviations consisted in congenital anomalies of position and shape.

The claim of the chiropractors that disorders of the stomach, the pancreas, and the kidneys are due to rotational displacement should be regarded with skepticism, since such a displacement rarely occurs in the area of the ninth to twelfth dorsal vertebrae, which represents the segmental levels for these organs.

Radicular pain in the lumbar spine has complex causes and is not due solely to rotational displacement, as the chiropractors claim. It may be attributable to disk lesions, telescoping subluxation of the facet joints such as is caused by disk atrophy, bony encroachment upon the intervertebral foramen, reflex irritation of the nerves due to facet-joint arthritis, spondylolisthesis, etc. In many cases a combination of several of these causes is responsible.

Five roentgenograms; 1 photograph.

WILLIAM A. MARSHALL, M.D.
Chicago, Ill.

Spinal Changes During Leukemia in Children. K. Gougleris, W. Swoboda, and H. G. Wolf. Fortschr. a. d. Geb. d. Röntgenstrahlen **88:** 309–318, March 1958. (In German) (Univ.-Kinderklinik Wien, Austria)

Only two-thirds of the cases of leukemia in children are said to show skeletal changes, and of these only a fraction involve the spine. Because of the rather common rheumatoid pain in the joints of the limbs, attention has been paid chiefly to the bony changes in the extremities.

The authors made routine studies of the spine in leukemic children and report 5 representative cases. The outstanding x-ray signs are severe osteoporosis, diminution of the height of the vertebral bodies with a biconcave appearance of the vertebral end-plates, and increase in the height of the disk spaces. A large section of the spine was usually involved. The most common location was the lower dorsal and the lumbar spine. It was found histologically that the osteoporosis was due either to displacement of bone tissue by a leukemic infiltrate or to diminution of the calcium content in connection with some alteration of its metabolism.

If the diagnosis of leukemia has not yet been definitely established by other means, the following differential diagnostic points have to be considered: Cushing syndrome may produce a similar appearance of the spine, *i.e.*, osteoporosis and a "platyspondylitic" appearance of the vertebral bodies. If the changes are localized in a small section of the spine, tuberculosis, septic spondylitis, lymphogranuloma, eosinophilic granuloma, etc., must be considered.

It should be kept in mind, also, that intensive cortisone therapy, such as is often given in leukemia, may produce a Cushing syndrome. The question then arises as to whether the x-ray findings in the spine are caused by the leukemia itself or possibly by the cortisone.

Twenty-one roentgenograms.

WILLIAM A. MARSHALL, M.D.
Chicago, Ill.

The Proximal End of the Femur. Investigations with Special Reference to the Etiology of Femoral Neck Fractures. Anatomical Studies. Roentgen Projections. Theoretical Stress Calculations. Experimental Production of Fractures. Stig Backman. Acta radiol. Suppl. 146, 1957. (Karolinska Sjukhuset, Stockholm, Sweden)

In this monograph, fundamental problems concerning femoral neck fractures are approached by a technical analysis of stress calculations and strength of materials. This has involved anatomical studies which, in turn, have yielded prerequisites for a new conception of the symmetrical structure of the upper femur, especially the head and neck. One chapter is devoted to roentgen projections of the femur, designated by the author "projections of symmetry of the femoral head and neck." The calculations on which positioning was based take into account the intravital pattern of femoral movements, all of which take place about axes passing through the center of the femoral head.

Detailed investigations of experimental fracture patterns within the proximal end of the femur are presented, and recommendations for osteosynthesis are supported, with slight variation to a more vertical entry of the fixation device. The historical review is detailed and compared enthusiastically with the author's findings.

Experimental studies include the production of fractures in 99 autopsy specimens.

Included are some observations on capsular injuries.

Seventy figures.

JOHN E. RHODENBAUGH, M.D.
The Henry Ford Hospital

Angle Measurement in the Diagnosis of Congenital Dislocation of the Hip. Gy. Justus. Radiol. clin. **27:** 65–68, March 1958. (In German) (Röntgenabteilung des Komitatsspitals in Salgótarján, Hungary)

Heretofore, the procedures recommended for the detection of congenital dislocation of the hip required visualization of the proximal femoral epiphysis. In the method described in this paper, this prerequisite is obviated, because the angle is determined by reference only to the acetabular rim. One line unites the most distant points of the rim formed by the ilium, while the other unites the two most distant points of that formed by the ischium. The angle between the lines is usually between 90 and 95°. In subluxations, the ileal portion of the rim is flattened, which increases the angle to 100° and beyond, sometimes to as much as 130°. This procedure is said to have been verified in several hundred instances. [The author does not specify whether the count included patients with and without dislocations, but it is assumed that both were included, as "several hundred" congenital dislocations of the hip would be seen in a routine radiological practice only over a long period—E. R. N. G.]

Three roentgenograms; 3 drawings.

E. R. N. GRIGG, M.D.
Cook County Hospital, Chicago

THE SPINAL CORD

Myelography with Positive Contrast Material. K. Decker. Fortschr. a. d. Geb. d. Röntgenstrahlen **88:** 277–287, March 1958. (In German) (Röntgenabteilung der Nervenklinik der Universität München, Germany)

The author reports his experience in making about 150 myelograms. For many of them air (or oxygen) was injected suboccipitally with the pelvis elevated.

Because the use of thin oils, such as Pantopaque and Ethiodan, has recently gained general acceptance, the author describes his technic.

A fluoroscopic tilt-table is used. A locking device keeps the screen at a certain predetermined distance from the table-top to avoid damage to the spinal puncture needle in the patient's back. In addition to the usual tube under the table-top, there is a second tube that permits taking films in a horizontal direction. The patient is placed in a prone position on the table, the thighs being fixed by means of a broad compression band. Sponge-rubber rings are ready to be placed under the chin to produce hyperextension, thereby preventing entry of the Pantopaque into the skull.

The puncture is made between the second and third or the third and fourth lumbar vertebrae. The area where disease is suspected should be avoided. Six cubic centimeters of Pantopaque is used for lumbar and 9 c.c. for cervical myelography. The table-top is raised to permit filling of the lower end of the spinal canal, and postero-anterior and oblique spot-films are taken of L-5 and S-1. The table-top is then lowered and films of L-3 and L-4 are taken. Lateral views with the rays parallel to the table-top are also obtained. The contrast material is routinely led up to the mid-dorsal area to avoid missing tumors in the lower dorsal region. The midportion of the dorsal spine is best seen by turning the patient into an oblique position. The upper dorsal spine can be well outlined by letting the contrast material run first into the cervical area (with the head strongly dorsiflexed); then, when the table is raised, the upper dorsal area will fill slowly.

The thin oil will outline an obstructing tumor and any abnormal finding should be tagged by a lead marker for later clinical identification of the location. The oil should by all means be prevented from flowing into the skull (by full dorsiflexion of the head) since, if it does so, it cannot be recovered. It should be removed through the spinal puncture needle as completely as possible.

Disk protrusion is usually recognized by a unilateral indentation in the oil column. Quite often the author found disk protrusions without clinical symptoms; on the other hand, a technically correct myelography may fail to demonstrate a disk protrusion.

The differential diagnosis between meningioma and neurinoma may be difficult or impossible. Gliomas can be recognized by a distention of the cord, sometimes with an irregular outer margin. A chronic adhesive arachnoiditis is characterized by multiple uneven changes in the outline of the oil column without a definite block. Hemangiomas are easily recognized, as they may be followed over a considerable distance and pulsation can sometimes be seen. An epidural tumor will compress the spinal canal, the oil column will appear generally narrowed, and the root pockets can no longer be identified.

Seven roentgenograms; 2 photographs.

WILLIAM A. MARSHALL, M.D.
Chicago, Ill.

Roentgenological Diagnosis and Differential Diagnosis of Intraspinal Tumors with Special Reference to the Clinical Symptomatology. W. Tönnis, G. Friedmann, and K. Nittner. Fortschr. a. d. Geb. d. Röntgenstrahlen **88:** 288–301, March 1958. (In German) (Neurochirurgische Universitätsklinik Köln, Germany)

Intraspinal tumors may be divided into intramedullary and extramedullary; the latter may again be subdivided into intradural (or juxtamedullary) and extradural (or epidural). The author analyzes 204 cases in which the diagnosis was verified by operation. Three-fifths were intradural, one-fifth intramedullary, and one-fifth extradural. The series included 58 neurinomas, 58 meningiomas, 24 gliomas, 14 ependymomas, 18 sarcomas, 22 angiomas, 5 lipomas, and 5 epidermoid tumors.

Aside from rather rare calcifications in the tumor itself, the most important roentgen signs are changes in the form of the pedicles and laminae and, particularly, widening of the distance between the pedicles. The tables of Elsberg and Dyke (Bull. Neurol. Inst. New York **3:** 359, 1934) show that in the various sections of the spine the horizontal interpedicular distance is rather constant, and widening by as little as 1 or 2 mm. may indicate a tumor. True sagittal anteroposterior views are absolutely essential to diagnosis. Inasmuch as the radiological changes may be slight, a thorough neurological examination should precede the x-ray examination so that the radiologist may know in which section of the spine a lesion is to be expected.

Neurinomas occurred most commonly in the thoracic spine. Radiological signs were partial atrophy of a pedicle due to pressure, widening of the interpedicular distance, widening of the intervertebral foramen (in hour-glass tumors), deformity of the laminae, and increased distance between the laminae of two adjoining vertebrae.

Patients with meningiomas were mostly women, of advanced age. The roentgen findings were similar to those for neurinoma, but less pronounced.

In contradistinction to the previously mentioned tumors, the roentgen findings for gliomas, ependymomas, and sarcomas extended for the most part over several vertebrae (3 or 4) and the pressure signs, such as widening of the interpedicular distance, were bilateral and rather symmetrical. Gliomas and ependymomas were almost exclusively intramedullary and were usually found in younger people. Sarcomas, however, occurred most often after the age of fifty. Common findings here were bone defects due to direct invasion of bone tissue.

Angiomas often involved the vertebral body, in which case their characteristic honeycomb-like appearance was demonstrated.

Lipomas and epidermoid tumors did not produce definite radiological signs.

The above-mentioned roentgen signs in the plain films were present in only 30 per cent of the cases, and the tumor had to be at least the size of a cherry to be demonstrated.

Whenever plain films show positive tumor signs, cerebrospinal fluid studies, a Queckenstedt test, and myelography should be done.

Fourteen roentgenograms; 3 graphs.

WILLIAM A. MARSHALL, M.D.
Chicago, Ill.

Arteriovenous Aneurysms of the Spinal Cord. A Report of Two Cases Investigated by Vertebral Angiography. Olle Höök and Hans Lidvall. J. Neurosurg. **15:** 84–91, January 1958. (Serafimerlasarettet, Stockholm, Sweden)

The authors report two cases of arteriovenous aneurysm of the spinal cord in which the diagnosis was confirmed by angiography of the vertebral artery. The

method used was that of Lindgren (Acta radiol. **46:** 257, 1956. Abst. in Radiology **68:** 883, 1957), in which a catheter is placed through the femoral artery into the aorta or subclavian artery. The diagnosis of spinal arteriovenous aneurysms is often difficult, though it may be suspected in instances where there is subarachnoid bleeding and small indentations are seen to impinge on the myelographic column. It is pointed out that the vertebral artery supplies both the cervical region and upper thoracic down to the level of T-4.

One of the authors' cases was of particular interest in that a loud murmur could be heard over the spine.

Five roentgenograms; a phonocardiogram.

HOWARD J. BARNHARD, M.D.
University of Arkansas Medical Center

The Prevention of Experimental Contrast Medium Injury to the Nervous System. P. D. Kenan, G. T. Tindall, G. Margolis, and R. S. Wood. J. Neurosurg. **15:** 92–95, January 1958. (Duke University School of Medicine, Durham, N. C.)

The authors tested various agents for their ability to protect the spinal cord against injury following the administration of radiopaque contrast material. These agents were administered through a catheter in the femoral artery prior to the injection of 1 c.c. per kilogram of 70 per cent Urokon. Preparations found to be relatively ineffective were Arfonad, papaverine HCl, heparin, varidase, and sucrose. Significant protection was afforded by glucose, 1–2 gm. per kilogram. Procaine, 25 mg. per kilogram, and hypothermia, stabilized at 27–29° C. before the injection and for one hour afterwards, were also quite effective. Possible mechanisms of action of these protective effects are discussed. It is stressed that, even though the mechanism of protective action is not well understood, glucose, being an innocuous agent, should be used as part of all clinical angiographic procedures.

One table.

HOWARD J. BARNHARD, M.D.
University of Arkansas Medical Center

THE GENITOURINARY SYSTEM

The Unilateral Nonfunctioning Kidney. D. E. Strandness, Jr. Arch. Int. Med. **101:** 611–619, March 1958. (4021st USAF Hospital, Dyess Air Force Base, Abilene, Texas)

The author studied 70 cases of unilateral nonvisualization of the kidney by intravenous pyelography and presents the results of this study, as well as a pertinent review of the literature.

From this study the following points are made:

(1) Extrarenal lesions which occasionally result in nonvisualization of one kidney are readily diagnosed by the combination of a plain x-ray film of the abdomen, cystoscopy, and retrograde pyelography.

(2) Disease of the kidney parenchyma, whether congenital or acquired, will present the greatest problems in diagnosis. (*a*) A kidney of normal size and architecture without function suggests renal artery thrombosis. (*b*) A kidney of small size with normal architecture without function suggests hypoplasia or renal artery thrombosis. (*c*) A small kidney with abnormal architecture without function suggests atrophic pyelonephritis or hypoplasia. (*d*) Aplasia or agenesis is suggested if the ureteral orifice is missing either alone or in combination with an absent trigone. (*e*) Ectopic implantation of the ureter and inflammatory obliteration of the ureter must be kept in mind when the ureteral orifice alone is not seen. (*f*) Retrograde pyelography will usually confirm the diagnosis of neoplasms, tuberculosis, and congenital malformation of the pelvis and ureter. (*g*) Aortography may aid in the diagnosis of neoplasms, renal artery thrombosis, aberrant renal artery, and agenesis.

(3) Neoplastic disease of the colon and female reproductive tract may cause nonvisualization of one kidney by extraluminal obstruction of the ureter.

Four roentgenograms; 2 tables.

THEODORE E. KEATS, M.D.
University of Missouri

Solitary Adenoma of the Kidney. Frederick C. Bauer, Jr., Don E. Murray, and Edwin F. Hirsch. J. Urol. **79:** 377–382, March 1958. (Presbyterian-St. Luke's Hospital, Chicago, Ill.)

The authors briefly review the pathology and clinical features of renal adenomas.

Adenomas of the kidney occur singly in otherwise normal kidneys and as single or multiple tumors in arteriosclerotic kidneys. Solitary adenomas are usually seen in younger persons, while those associated with arteriosclerotic kidneys are usually seen after the age of forty. Histologically the adenomas are said to be of three types: papillary, alveolar, and tubular. There is lack of agreement on the classification, however, so that the relative incidence of the three types cannot be accurately stated. The authors do state, however, that alveolar adenomas are rare.

Transition from adenoma to carcinoma has been described, but this has not been seen in the multiple adenomas of arteriosclerotic kidneys. The difference between adenoma and adenocarcinoma frequently cannot be accurately determined histologically. Therefore, all adenomas greater than 2 inches in diameter are considered potentially malignant.

Clinically, adenomas present most commonly as a mass. Hematuria is seen less often and pain, when it occurs, is attributed to the passage of clots or pressure on adjacent structures. Radiographic studies may show a soft-tissue mass, and urography a smooth distortion of the renal pelvis with elongation of one or more of the calyces. The latter is often so slight that it is overlooked.

A case history is presented.

Two photomicrographs; 1 photograph.

S. DAVID ROCKOFF, M.D.
University of Pennsylvania

Anuria Following Retrograde Pyelography. Harry M. Burros, V. H. J. Borromeo, and I avid Seligson. Ann. Int. Med. **48:** 674–676, March 1958. (H. M. B., 255 S. 17th St., Philadelphia 3, Penna.)

The authors report an unusual case of anuria following retrograde pyelography with Skiodan, 15 per cent.

Following injection of 2 c.c. of the medium (of an intended 8 c.c.) into both sides simultaneously, the patient complained of severe back pain in both costovertebral angles. The blood urea nitrogen rose from 13 to 56 mg. Serum creatinine was 3.2 mg. per cent. The patient was treated supportively with intravenous administration of fluids, sodium lactate, and analgesics. Intolerable pain continued, however, and anuria persisted for seventy-two hours. Cystoscopy under general anesthesia at the end of that time revealed 30 c.c. of urine in the bladder. Both ureteral orifices were inflamed

and edematous. On catheterization, 300 c.c. of urine were obtained from the left side and 275 c.c. from the right. Both catheters were fixed in position. Following this procedure, the patient was entirely free of pain and was discharged on the fifth day, with blood urea nitrogen 32 mg. per cent and serum creatinine 1.5 mg. per cent.

The cause of anuria in this case is thought to have been extensive edema of both ureters resulting from a local sensitivity reaction to the contrast material. This was further suggested by a positive intradermal test done on the second day of anuria.

Review of the urological literature revealed no similar case.

HARRY GAZELLE, M.D.
Cleveland City Hospital

Periureteritis Obliterans: a Retroperitoneal Inflammatory Disease. William P. Mulvaney. J. Urol. **79:** 410–417, March 1958. (19 Garfield Place, Cincinnati 2, Ohio)

Periureteritis obliterans may be described as a unilateral or bilateral hydronephrosis and hydroureter having as its cause a mass of inflammatory fibrous tissue compressing and enveloping a segment of the midureter. It probably originates from a lower genitourinary tract infection.

Three cases are reported in each of which the midureter was enveloped by an extremely dense, matted, fibrous tissue mass extending laterally over the posterior abdominal muscles and medially across the psoas muscle. The lumen of the ureter was reduced in each case and almost obliterated in 2. In 1 case tissue cultures produced growth of *B. aerogenes* and hemolytic *Staphylococcus albus*, sensitive to chloromycetin; paracolon intermediate bacteria were found in the periureteral tissues in the second case; in the third, urine and periureteral cultures produced a growth of *B. aerogenes*.

The appearance of the lesion when visualized by retrograde pyeloureterography can be said to be typical. A good ureterogram is essential to assess the involvement accurately and to plan the surgical treatment. Since it may be impossible to pass an ordinary ureteral catheter through the narrowed segment, the use of a bulb type ureteral catheter, which gives by far the best demonstration of the disease, may make a difficult diagnosis certain. Neomycin added to Skiodan is suggested to lessen the hazard of pyelography.

The finding of hydronephrosis with hydroureter in the upper third with segmental constriction of the midureter should suggest the diagnosis of periureteritis obliterans. An extremely short area of constriction is easily confused with stricture. Inadequate filling of the ureter in cases of hydroureter can simulate the disease. It has been reported that at times the fibrous mass is large enough to be palpated through the abdomen and confused with neoplasm.

Treatment should be conservative, if possible, with corrective surgery rather than nephrectomy. In segmental ureteral damage, resection of the ureter is suggested.

Twelve roentgenograms; 1 photograph.

Neocystoscopy and Neocystography. George T. Mellinger and Paul B. Klatte. J. Urol. **79:** 459–462, March 1958. (VA Hospital, Cincinnati, Ohio)

In an attempt better to evaluate the urinary tracts of patients on whom ileal bladder substitution procedures have been performed, the authors have designed two technics which they term "neocystoscopy" and "neocystography." The former refers to the cystoscopic examination of the isolated ileal segment, either with or without retrograde pyelography; the latter is the author's coined word for the radiographic examination of the ileal bladder substitute filled with a radiopaque medium. These technics have been valuable in assessing the postoperative status and have been employed as early as twenty-four hours after surgery, as well as a year later.

In instances where diminished renal function makes radiographic visualization difficult in excretory urography, neocystography is particularly helpful.

The technics are described in detail. For neocystography the authors use a Foley catheter placed in the ileal segment, with the bag distended by sterile water to prevent reflux outward. Under 35 mm. of water pressure, 20 per cent Skiodan with 1 per cent Neomycin is introduced. Good filling of the kidneys and ureters as well as the ileal segment is achieved.

Five figures including 3 roentgenograms.

FRED J. MUNSON, M.D.
University of Pennsylvania

THE ADRENALS

Roentgen Examination of the Suprarenal Glands. Stig Fagerberg. Acta radiol. **49:** 218–226, March 1958. (University Hospital, Upsala, Sweden)

Retroperitoneal pneumography performed in 90 cases of suspected suprarenal disease and 50 abdominal aortographic examinations performed chiefly on renal indications form the basis for this report.

Since the suprarenal space encloses both the adrenal and the fatty layer in which it is enveloped, incorrect radiologic judgments are easily formed concerning the actual size of the gland. The normal structures located in the region of the adrenals, such as the tail of the pancreas, an accessory spleen, or the fornix of the stomach, may also be visualized and lead to misinterpretation of x-ray films. Nevertheless, if findings are viewed with caution, retroperitoneal pneumography probably is the best presently available method for demonstrating expanding suprarenal lesions.

On aortography the fine suprarenal vessels fill incompletely in about 50 per cent of cases; their identification is very difficult due to superimposition of the hepatic and splenic artery shadows. In a few large adrenal tumors of this series, the study was helpful, showing pathologic vascularization of the tumor and displacement of the renal artery.

Nine roentgenograms; 2 tables.

DON E. MATTHIESEN, M.D.
Phoenix, Ariz.

SOFT TISSUES

Roentgenographic Studies of Cutaneous and Subcutaneous Infiltrates in Erythema Induratum and Erythema Nodosum. C. G. Leczinsky and O. Mattsson. Acta radiol. **49:** 193–204, March 1958. (Karolinska Sjukhuset, Stockholm, Sweden)

X-ray studies of the soft tissues reveal differences in appearance, often diagnostic, in the lesions of erythema nodosum and erythema induratum. Examinations should be made on nonscreen film, at 40 to 50 kvp. Centering is best performed under fluoroscopic control with an image intensifier. Field size should be very small to reduce secondary radiation.

Erythema nodosum basically presents changes of vessels and fibrous tissue. Here films show that the cutis is thickened, and its lower border against the subcutis is indistinct. The cutis passes gradually into a network of coarse fibers which merges into the normal tissues below as the fibers become finer and more sparse.

The lesions of erythema induratum represent changes of vessels and fat tissue. Radiologically they show a well defined line of demarcation between cutis and subcutis. The fibers and septa of this group are more slender and less distinctly seen, so that the subcutis shows a more or less diffuse increase in density.

Twenty cases of lesions of the lower legs are reviewed. Seventeen roentgenograms; 2 photomicrographs.

DON E. MATTHIESEN, M.D.
Phoenix, Ariz.

TECHNIC

Ultrashort (Millisecond) Timing and a Rapid Film Changer in Pediatric Radiography; Evaluation of Dynapulse and Impulse Timing. Barton R. Young, Robert B. Funch, and Jay W. MacMoran. J. Dis. Child. **95:** 300–304, March 1958. (Germantown Hospital, Philadelphia 44, Penna.)

Observations on twenty months experience with a Dynapulse timer capable of exposures as short as 1/1000 second are presented. In addition, a new rapid film changer (Franklin) which uses 14-inch-wide roll film and moves up to six 11-inch segments per second is described.

Pediatric chest films made with millisecond exposures and with impulse timers using 1/120 and 1/60 second exposures were analyzed by four observers independently, and no diagnostic differences could be detected. Radiography of the extremities was also done with both timers, with equally good results, as anticipated. Similarly, there was no difference in unsharpness on angiocardiograms obtained on the same dog at 1/120 and 1/1000 second when all other factors were equal. However, a more critical test with a fine wire mesh revolving on a spinning disk of known speed revealed an obvious difference. Motion of about 100 cm. per second, which approximates the estimated rate of human blood flow, was "stopped" by a millisecond exposure, while motion over 20 cm. per second was blurred with the fast impulse timer.

It is felt that the use of ultrashort exposures will reduce the number of re-examinations and, therefore, the radiation hazard. The authors point out that millisecond exposures in angiocardiography will not obviate the need for rapid serialography.

Five roentgenograms; 2 photographs.

LAWRENCE A. POST, M.D.
University of California, S. F.

RADIOTHERAPY

A Study of Metastatic Carcinoma of the Neck. David L. Kinsey, Arthur G. James, and Joseph A. Bonta. Ann. Surg. **147**: 366–374, March 1958. (The Ohio State University Medical Center, Columbus, Ohio)

One hundred and fifty cases of metastatic carcinoma in the cervical region, originating in the head and neck, are presented. In 109 cases the primary site was intraoral; 33 tumors arose from the neck and in 5 cases the primary site was undetermined. The presenting complaint in 52 cases was a lump in the neck. In 72.6 per cent of cases the primary lesion could be visualized directly, in 11.3 per cent it could be palpated, and in 10.6 per cent simple mirror examination of the nasopharynx was sufficient to reveal it.

The submaxillary node was the most frequent metastatic site (67 cases). The upper jugular node was involved in a third of the cases. The middle jugular nodes were invaded by thyroid and laryngeal carcinoma, as were also the lower jugular nodes. The submental nodes were involved by carcinoma primary in the lip and gingiva. The posterior accessory nodes were involved from the nasopharynx, thyroid, and tonsil. The prevailing cell type was epidermoid carcinoma (134 cases), with a few adenocarcinomas (10 cases) and undifferentiated carcinomas (6 cases).

Confirmatory microscopic diagnosis was obtained by aspiration biopsy in 96 of 101 of the presented cases. It was performed as an office procedure under local anesthesia. No morbidity and no adverse effects, such as seeding of tumor or interference with subsequent surgery, were experienced.

The authors advocate radical neck dissection as the basic operative procedure for metastatic carcinoma. In the cases of resectable primary lesions combined radical neck dissection and excision of the primary tumor in continuity is advocated. Radiation therapy is recommended only for lesions noncurable surgically and as an adjunct to operation. The authors utilized surgery combined with interstitial radiation in 31 cases.

In 45 cases of this series followed for five years the cure rate was 33.3 per cent.

One roentgenogram; 2 photographs; 7 drawings; 3 tables.

ROBERT S. ORMOND, M.D.
Dearborn, Mich.

Experiences in the Treatment of Inoperable Carcinoma of the Lung with 2 mv. and Cobalt 60 Irradiation. Ruth J. Guttmann. Am. J. Roentgenol. **79:** 505–510, March 1958. (Francis Delafield Hospital, New York, N. Y.)

The author previously reported a series of 100 patients who had been treated for far advanced, inoperable carcinoma of the lung at the Francis Delafield Hospital, New York City (Cancer **8:** 1254, 1955. Abst. in Radiology **68:** 303, 1957). Two-million-volt irradiation was used on these patients with subjective and objective good results. The present report is a follow-up of the original study, including a brief summary of the type of patient material, with the addition of 44 patients subsequently treated. Ten of the recent cases have been treated with the cobalt-60 unit.

It is the author's opinion that rotation therapy, or scanning, does not offer any advantage because much of the healthy neighboring tissue is exposed to irradiation unnecessarily. The present approach has been through two large opposing fields on the 2-mv unit with an h.v.l. of 7 mm. of Pb at a target skin distance of 100 cm. The daily tumor dose was 200 r for a total tumor dose of 5,000 to 6,000 r in five to six weeks. Tolerance to this

type of irradiation has been excellent. The easy and efficient approach possible with the 2-mv unit cannot be duplicated with a cobalt-60 unit because of the difference in the isodose pattern. There is a considerable fall-off at the margins, which makes a larger field necessary with the cobalt unit, thus including more of the healthy tissue.

Evaluation of the results of the combined series confirms the previous impression that a very high percentage of the patients benefited greatly from the treatment and showed excellent symptomatic improvement. Roentgenographically, the majority of the patients showed relatively little change. The author presents several cases illustrating the unchanged appearance of the chest film, but with dramatic improvement in symptoms. One-third of the patients were kept alive for more than one year after completion of treatment; 48 survived in decreasing numbers for a steadily increasing number of months; 4 lived for a period exceeding four years.

Among the observations made in the course of this special study are three of considerable interest: (1) absence of correlation between clinical success and roentgenological findings; (2) the apparently greater response of malignant lesions of the epithelium compared with those of glandular tissue; (3) the microscopic proof that it is possible to sterilize even a large carcinoma of the lung with external radiation as outlined.

Seven roentgenograms; 4 drawings; 3 charts; 1 table.

NORMAN L. ARNETT, M.D.
Upland, Calif.

Adenocarcinoma of the Lung Treated with X-Ray and Nitrogen Mustard——Five Years from Discovery to Death. Joseph J. Arons, Albert C. Daniels, and Russell W. Bernhard. California Med. **88:** 240–244, March 1958. (J. J. A., 711 D St., San Rafael, Calif.)

A 74-year-old man was found, by bronchoscopic examination and biopsy in October 1949, to have adenocarcinoma of the lung. In early 1950 he underwent external roentgen therapy through three moderate-sized chest portals aimed at the tumor of the right main bronchus, 2,000 r being delivered to each port in seven weeks, with conventional x-ray qualities. Six months later the mass had decreased in size and the symptoms were much improved. Bronchoscopy eleven months after the initial diagnosis showed no evidence of tumor and no neoplastic cells were found on sputum study. In July 1952, it became evident that a mass was developing in the region of the right middle lobe bronchus without bronchial obstruction. A short course of radiotherapy was given through large, anterior and posterior chest fields, followed by 30 mg. of nitrogen mustard intravenously and an unspecified amount of corticotropin. The patient then improved considerably and remained reasonably well until shortly before his death in December 1954, at the age of eighty.

Postmortem examination showed complete collapse of the right lung, with strong shift of the mediastinum to the right. There was no gross evidence of residual or metastatic tumor. However, microscopic studies of the right main bronchus and adjacent mediastinal lymph nodes revealed small nests of tumor cells.

The authors concluded that "carcinoma of the lung is not always a hopeless disease as far as theory is concerned . . . radiation therapy may be worthwhile." A short review is given of the results of others in carcinoma of the lung.

Three roentgenograms; 2 photomicrographs; 3 tables.

JAMES W. BARBER, M.D.
Cheyenne, Wyo.

Treatment of Bladder and Prostatic Cancer by Combined Interstitial Isotope Radiation and the Cobalt Bomb. Carl F. Rusche and Henry L. Jaffe. J. Urol. **79:** 474–489, March 1958. (C. F. R., 1400 N. Vermont Ave., Los Angeles 27, Calif.)

A clinical classification of bladder tumors is presented, with a method of treatment for each group. In particular, a procedure combining the injection of radioactive colloidal chromium phosphate and external cobalt bomb therapy is described for both advanced bladder cancer and carcinoma of the prostate. By this technic it is possible to deliver high tumor doses and to direct treatment accurately to the area of involvement, with minimal damage to the surrounding normal tissues. If properly applied, this combined method is well tolerated and does not appear to produce any serious complications. The radiation reaction in the skin is minimal and there is relative absence of radiation sickness, in spite of the fact that a very large tumor dose is delivered. There is a striking absence of secondary contracture of the bladder following cobalt bomb therapy as compared to the contracture which usually follows intensive conventional x-ray therapy.

Preliminary results of cobalt teletherapy (with and without radioisotope injection) in 36 cases of bladder cancer and 15 cases of prostatic cancer are reported. "Good" results are claimed in 16 of the bladder cases and in 8 of those with prostatic disease.

Ten figures, including 2 roentgenograms; 3 tables.

L. MURRAY HOUSER, M.D.
University of Pennsylvania

Clinical Significance of Rectal and Bladder Dose Measurements in Radium Therapy of Cancer of the Uterine Cervix. Gilbert H. Fletcher, Thomas C. Brown, and Felix N. Rutledge. Am. J. Roentgenol. **79:** 421–450, March 1958. (G. H. F., M.D., Anderson Hospital and Tumor Institute, Houston, Texas)

The authors review their experience in 500 cases of squamous-cell carcinoma of the uterine cervix receiving intracavitary radium therapy between 1948 and 1954. These are divided into two groups, the first group treated up to 1952 and the second group treated thereafter. In the second group, direct bladder and rectal measurements were taken routinely in all radium insertions. This information, in addition to the calculations of the volume distribution in the pericervical and parametrial areas, was found to be useful in individualizing treatment. As a result of more direct dosimetry, the incidence of rectal complications was sharply reduced in the second series and the rectal reactions were of milder type. Among the many interesting comments which the authors make concerning rectal and bladder complications, the following are worth noting:

1. There is no evidence of absolute level for irradiation tolerance of the bladder and rectum and one cannot set up radium technics based on these figures. Tolerance levels given in the literature for bladder and rectum have little meaning because there is no information regarding treatment time, dosage rate, and there is no series in which individual complications could be correlated with physical data.

2. There is a wide margin of dosage levels within which an increase in the incidence of complications will

probably occur. Associated factors, such as racial characteristics and anatomic anomalies, are of importance in this respect.

3. Complications in the bladder and rectum are rare in early cases even without the help of dosimetric procedures. The individualized dosimetric procedures as used by the authors are particularly valuable in late stages of the disease.

4. There is no correlation, at least in this study, between rectal and bladder high dose effects and doses at Point A and Point B. In fact, the authors give the impression that information regarding dosage at these points is of little value in managing the individual case. [The reviewer considers this article an important contribution, well worth reading in the original.]

Nineteen roentgenograms; 4 drawings; 1 graph; 12 tables. D. D. ROSENFELD, M.D.
Fontana, Calif.

Moving Field Radiation of Gynecological Tumors in the True Pelvis. VI. Convergent Beam Roentgen Therapy of the Parametria, with Particular Attention to Dose Distribution in the True Pelvis. Philipp Müller. Radiol. clin. **27:** 92–113, March 1958. (In German) (Fichtenstrasse 76, Fürth/Bayern, Germany)

Measurements taken in a water phantom, irradiated with convergent beam technic, reveal very promising isodose curves, indicating that a desirable build-up can be produced at will in any particular area. To test the validity of this procedure in the treatment of parametria, the author suspended a bony pelvis in a water phantom, and thus approximated the conditions encountered in a very thin individual. Convergent irradiation was applied to the phantom with 200 kvp, 20 ma, 0.5 mm. Cu (h.v.l. 1.0 mm. Cu), at a distance of 9 cm., with 2-, 3-, and 4- cm.- collimators, the converging center(s) being directed to the expected location of the parametria. Measurements were made with the instant dosimeter Bomke, of German manufacture, with an ionization chamber of only 16.7 cu. mm.

It soon became apparent that the size of the ionization chamber caused considerable variation in the results. Moreover, the presence of the bony girdle was responsible for noticeable changes (hot spots and otherwise dyshomogeneous dose distribution), to the point where it was practically impossible to predict with any degree of accuracy prior to actual measurement what the dose would be at a given point.

The author concludes by questioning the wisdom of employing convergent beam technics in the supplemental irradiation of the parametria after radium therapy for carcinoma of the cervix.

Twenty-six figures, including 1 photograph.
E. R. N. GRIGG, M.D.
Cook County Hospital, Chicago

Physical Aspects of Rotation Therapy. H. E. Johns. Am. J. Roentgenol. **79:** 373–381, March 1958. (Ontario Cancer Institute, Toronto, Ont., Canada)

The author contrasts the preoccupation with skin dose in fixed field radiation therapy with the emphasis on tumor dose in rotation therapy. He discusses the concept of the tumor-air ratio and illustrates its usefulness in calculation of tumor dose in rotation therapy. Applicability of tumor-air ratio calculation is greatest when treatment is directed to a relatively homogeneous portion of the body. Discussed also is the calculation of tumor dose when inhomogeneities are present, as for example in the treatment of a mediastinal tumor. Accurate calculation under these conditions is, according to the author, best achieved by measuring the transmission of the therapy beam through the use of a focusing ionization chamber.

The author mentions the fact that penumbra is related to the relative position of the collimating diaphragm, as well as to source size, and recommends that increased focal tumor distances be employed in radiation therapy to allow collimation to be performed as far from the source as is practical, which will effect a reduction in penumbra. He points out that penumbra contributes considerably to the integral dose which the body receives during therapy, which may be quite important if critical organs lie in the high-dose region.

Because rotation therapy depends upon accurate localization of the tumor from all portals of entry, the author discusses various methods which have been utilized to obtain the necessary accuracy. In solution of this problem and of the one concerning penumbra size, he describes a cobalt-60 unit which has been designed by the radiation therapists and physicists of the Ontario Cancer Institute. The unit may be utilized in fixed-field therapy at a source-to-skin distance of 80 cm., or for rotation therapy at a source-to-axis distance of 95 cm. The head of the unit incorporates a diagnostic x-ray tube which can be utilized to obtain fluoroscopy or films through the therapy port for accurate localization. The cobalt source is retracted from the diagnostic beam during localization and then is repositioned over the port for therapy. The counterweight arm of the device contains a back-pointing light localizer and also a focusing ionization chamber for transmission dose measurement.

Eight figures; 2 tables. JAMES E. BAUER, M.D.
Victoria, Texas

Rotation Therapy at 250 Kv. Robert Robbins and K. C. Tsien. Am. J. Roentgenol. **79:** 394–399, March 1958. (3401 North Broad St., Philadelphia 40, Penna.)

In comparing rotation therapy with 250-kv x-rays to that with cobalt 60, the authors state they have used the former for five years, the latter for one. They find that cobalt-60 therapy in the pelvis, utilizing a field size of 14 x 20 cm. at the axis, gives a homogeneous dosage in the field and a better fall-off of dose outside the field than conventional 250-kv roentgen rays with a h.v.l. of 1.7 mm. Cu. However, they also find that with 250-kv rotation therapy the dose in depth is higher than that on the skin, with a homogeneous dose in depth.

The authors state that they have calculated the integral dose and observed its effect for several years. While they agree that, all things being equal, there is no question that the technic giving the smaller integral dose should be used, they have been unable to correlate integral dose with observable clinical effect and have minimized the importance of this factor for practical purposes.

Some practical experiences dealing with shielding difficulties, area differences, and penumbra effect are recounted. In treating a lesion of the nasopharynx with complete rotation, the authors found it convenient to use 250-kv x-rays rather than the cobalt-60 apparatus because lead shielding of the eyes is much more efficient with the former radiation. In using cobalt-60 rotation therapy in the nasopharynx they found it necessary to resort to partial rotation, which with their unit is not

accomplished to the degree of accuracy they would desire. The field size setting on the cobalt-60 unit employed by the authors is the area enclosed by 50 per cent isodose lines. [This may well be the case with other cobalt-60 units.—J.E.B.] It is believed that the field size at 250 kv corresponds to the 80 per cent isodose lines. Apparently, even a simple statement of field size introduces some uncertainty, not only in dose distribution, but in dose level as well.

The authors discuss the problem of a wide penumbra (such as occurs in cobalt-60 therapy units) and consider this a serious limitation which demands a practical solution. [Readers are referred to the article by Johns abstracted above.]

It is concluded that in many situations where the superiority of cobalt-60 rotation over 250-kv rotation is not clear, the latter may have advantages in economy, shielding, penumbra, and localization filming which establish for 250-kv rotation a valid place in modern therapy.

Seven figures. JAMES E. BAUER, M.D.
Victoria, Texas

Consideration of Rotation Therapy with the 22.5 MEV. Betatron. Morton M. Kligerman, Norah duV. Tapley, and Ginette Jacob. Am. J. Roentgenol. **79:** 387–393, March 1958. (M.M.K., 789 Howard Ave., New Haven, Conn.)

The authors cite the theoretical desirability of rotation therapy in several clinical situations. They set forth the results of their experiments in determining the dosage distribution, achieved in rotation therapy of typical treatment situations, with the 22.5-MEV betatron x-rays, cobalt-60 teletherapy beams, and 250-kv x-rays. Isodose diagrams representing cross sections of the dose distribution achieved in the therapy of large central head lesions, large eccentric head lesions, small eccentric chest lesions, and large central chest lesions are presented. The measurements were obtained in a human-shaped Presdwood phantom.

The conclusions drawn from the authors' experiments are as follows: "Rotation therapy with the betatron in general gives excellent delineation of the high tumor dose to the area of interest, yielding remarkably low doses in the non-tumor-bearing tissue as well as the skin." They state that this is achievable without regard to size or location of the lesion.

When a Presdwood phantom of the chest, with the area of the lungs occupied by cork, is used, the dose to the tumor with betatron rotation is 4 per cent higher than the calculated tissue dose, which disregarded the lung. A similar lesion treated with three fixed ports would receive 3 per cent more than calculated, while the lung would receive a dose 6 per cent lower than calculated. With cobalt-60 the dose is 10 per cent higher at the tumor than that calculated on the basis of the unit density material. With 250 kv, the dose at the tumor is 17 per cent higher and in the lung 5 per cent higher than that calculated on the basis of the unit density material.

The calculations for the various treatment sites were made for cobalt-60 beams with wide penumbra and also with excellent collimation. The authors conclude that rotating cobalt-60 beams with large penumbra do not offer significant physical advantages over 250-kv rotation except in regard to skin reactions.

Eight figures. JAMES E. BAUER, M.D.
Victoria, Texas

Three Years' Clinical Experience with Rotation Therapy with the Theratron. John H. Maus and Norman A. McCormick. Am. J. Roentgenol. **79:** 382–386, March 1958. (J.H.M., Metropolitan General Hospital, Windsor, Ont., Canada)

The authors survey their experience over a three-year period with cobalt-60 rotation therapy with the Theratron. Only 29 per cent of new patients with cancer admitted to the Ontario Cancer Foundation Windsor Clinic during the past three years were thus treated. The remainder were apparently treated with conventional x-ray apparatus, interstitial sources, or surgery. Thirty-six per cent of the patients receiving cobalt-60 beam therapy were treated by rotational technic. In approximately 90 per cent of this group fields 10 × 10 or 15 × 15 cm. were used.

The authors have calculated the integral dose resulting from cobalt-60 rotation therapy of the pelvis for gynecologic cancer, and also for three pairs of intersecting parallel opposing fixed fields. These figures they compare with similar figures for roentgen rays of 3.0 mm. Cu h.v.l., for a tumor dose of 6,060 roentgens. Their results indicate that cobalt-60 therapy results in an integral dose of approximately half that which would be received if conventional x-ray apparatus were used in the same manner. [It should be noted that the integral dose resulting from conventional combination x-ray and radium therapy of carcinoma of the cervix may be considerably less than that which was calculated by the authors for roentgen rays alone.—J.E.B.]

Criteria for suitability of patients for rotation therapy are set forth. Because rotation therapy has been to some extent reserved for those cases deemed to be advanced or even incurable, comparison of results is not in order. The authors do state that in carcinoma of the esophagus palliation has been superior to that obtained by any other method in patients previously treated in their institution for this disease.

Technics are described for treatment of cancers in various locations with cobalt 60 rotation therapy. Tumor doses have averaged 1,000 roentgens to the tumor per six-day week for treatment periods ranging from four to ten weeks.

Four tables. JAMES E. BAUER, M.D.
Victoria, Texas

The Evaluation of the Dose to the Thorax in Rotational Cobalt 60 Therapy. T. E. Burlin. Brit. J. Radiol. **30:** 543–549, October 1957. (Mt. Vernon Hospital, Northwood, Middlesex, England)

At the Mount Vernon Hospital (Middlesex), from which this contribution comes, the treatment of malignant neoplasms of the thoracic cavity on the Theratron Co^{60} unit is almost invariably by a complete rotation technic. The correction of the roentgen dosage under these conditions has been attempted by measuring the intensity of the primary radiation transmitted through the patient. This is done with a small-volume ionization chamber mounted on the counterweight of the Theratron. Scattered radiation is excluded by a tubular brass-lined collimator whose incident end is covered with a 1-mm. Cu plus 1-mm. Al filter.

The measured dose in a 10-cm. air space in a Mix D phantom was found to be 12 per cent below the dose calculated on the basis of the effective outline obtained by the transit dose determinations. Therefore, dose measurements were made in an inhomogeneous phantom.

Measurements on the emergent side of a 15 × 15-cm. volume of air or sawdust of the density of lung tissue showed a build-up of ratio to water phantom measurements in the first 6 cm., this being less for sawdust than for air. In both cases this ratio was independent of depth of the inhomogeneity and of source-skin distance. A table of scatter-correction factors is given for air and lung.

The dose deficit on the incident side of the inhomogeneity was never more than 2 per cent. The final correction factor obtained for complete rotation for thoracic cases is $0.94\ e^{+\mu(R_a - R_e)}$ where R_a and R_e are the actual and effective radii of the patient.

One drawing; 4 graphs; 1 table.

LUCILLE DU SAULT
The Henry Ford Hospital

Note on Output Variation of Medical Van de Graaff Unit. Martin L. Rozenfeld. Am. J. Roentgenol. **79:** 415–420, March 1958. (Argonne Cancer Research Hospital, Chicago 37, Ill.)

The roentgen-ray output of a Van de Graaff therapy unit has been found to vary with the angle of the machine. In the horizontal position, the output is 10 per cent higher than in the vertical position, even though the physical alignment and control panel settings are the same. The author reports experimental studies and offers a method for correcting the output variation.

The variation was found to be due to an error in the measurement of the high voltage on the insulated hemisphere. The voltage is measured by a generating voltmeter mounted on the pressure housing. When the machine is angled toward the horizontal, the central column deflects slightly, moving the hemisphere away from the generating voltmeter. This reduces the generating voltmeter output. In order to maintain the same voltage reading, the high voltage must be increased, thereby increasing the roentgen-ray output in the horizontal direction. One way to eliminate this variation would be to relocate the generating voltmeter so that it faces the top of the hemisphere. The deflection of the central column would then produce an insignificant change in the distance between the generating voltmeter and the hemisphere. Most existing units, however, require a less expensive method. A simple and inexpensive way to compensate for the changing current from the generating voltmeter is to introduce a variable shunt across the meter that measures the generating voltmeter current.

The author presents several graphs to support the experimental evidence, and also presents the mathematical computations necessary to calculate the resistance variations required by the variable shunt.

Eight figures; 2 tables.

NORMAN L. ARNETT, M.D.
Upland, Calif.

RADIOISOTOPES

Localization of Brain Tumors at Operation with Radioactive Phosphorus. An Improved Technique Using a Proportional Counter. Charles V. Robinson and Bertram Selverstone. J. Neurosurg. **15:** 76–83, January 1958. (New England Center Hospital, Boston, Mass.)

Following intravenous injection, radioactive phosphorus is taken up in greater amounts by a brain tumor than surrounding tissue. The authors report a new probe with which to locate these areas of increased uptake. Their old probe was of the Geiger-Müller type and had a somewhat elongated sensitive region which was proximal to the end of the probe. The present probe has a shorter sensitive length located at the very tip. It is more rugged and has a longer life than the earlier one, and is of the proportional type. Ten cases in which the new probe was used are presented and its advantages are listed as follows: (*a*) Less penetration of the brain or tumor is required. (*b*) Demarcation of the tumor is more precise. (*c*) Counting with the shielded sensitive tip can be done on the surface of an exposed lesion. This is particularly useful in regions where probing would be unsafe.

Five figures; 1 table.

HOWARD J. BARNHARD, M.D.
University of Arkansas Medical Center

A New Isotope Method for Detecting Continued or Recurrent Bleeding After Subarachnoid Hemorrhage. Sanford F. Rothenberg, Ernest J. Penka, and Richard W. Garrity. J. Neurosurg. **15:** 215–222, March 1958. (S. F. R., 450 N. Bedford Drive, Beverley Hills, Calif.)

In an effort to provide a simple reliable means of following more accurately the course of subarachnoid hemorrhage, the authors have developed a new method of demonstrating "active bleeding" into the cerebrospinal fluid. The procedure depends on the fact that intravenously injected red blood cells tagged with chromium 51 can be detected promptly in the spinal fluid when active subarachnoid bleeding takes place. The findings in 8 patients with spontaneous subarachnoid hemorrhage and in 15 normal individuals are described.

The authors state that, by utilizing this procedure, one can determine whether or not bleeding into the subarachnoid space has been arrested, is continuing, increasing, or is continuing intermittently. What can be gained by knowing whether or not there is active bleeding rests with further experience, acquired through a study of more patients. It may be possible to improve the timing for arteriography. It may also help to separate those patients who should be treated early surgically from those who should be treated medically. This would decrease the mortality rate in patients in whom surgical measures are hazardous and improve the chances of cure in those requiring early surgical treatment.

Five charts.

Measurement of Red-Cell Loss from Gastro-Intestinal Tract, Using Radioactive Chromium. N. C. Hughes Jones. Brit. M. J. **1:** 493–496, March 1, 1958. (Postgraduate Medical School of London, London, W. 12, England)

Previous studies have shown that when radioactive chromium-labeled red cells are introduced into the stomach or duodenum, over 90 per cent of the radioactive material can be recovered in the feces. Experiments were made to estimate quantitatively the amount of blood lost in stools by labeling a sample of the patient's red cells with radioactive chromium, re-injecting

the cells into his circulation, and subsequently determining the ^{51}Cr content of the stools. Such investigations were carried out on 6 patients known to be bleeding from the gastrointestinal tract. The author's own summary analyzes the results well and is quoted in part.

"As expected, the rate of loss of ^{51}Cr from the blood stream was increased, and this was almost completely accounted for by the amount of ^{51}Cr lost in the stools. The fact that the amount of ^{51}Cr lost in the stools did not completely account for the rate of loss of ^{51}Cr from the blood stream indicates that some ^{51}Cr is reabsorbed from the gastro-intestinal tract (but is not reutilized). Thus the ^{51}Cr method slightly underestimates the amount of blood lost in the stools.

"In two control subjects who were thought not to be bleeding into the gastro-intestinal tract, the amount of ^{51}Cr excreted in the stools following the intravenous injection of ^{51}Cr-labelled cells was very small (equivalent to 0.1 to 0.2 ml. of red cells a day). Because of this slight excretion of ^{51}Cr in the stools of normal subjects whose cells have been labelled with ^{51}Cr, the daily loss of blood in the stools must exceed 1 ml. a day before it can be detected by this method."

Data on the 6 studied cases are presented in table and graph form. It is evident from the graphs that the residual radioactive chromium in the blood of patients bleeding into the gastrointestinal tract is considerably less than that expected in normal individuals at any measuring interval. Mathematical calculations are presented.

Three graphs; 2 tables. JAMES W. BARBER, M.D.
Cheyenne, Wyo.

Further Observations on the Use of I^{131}-Labeled Lipids in the Study of Diseases of the Gastrointestinal Tract. Julian M. Ruffin, Ivan C. Keever, Crockett Chears, Jr., William W. Shingleton, George J. Baylin, Joseph K. Isley, and Aaron P. Sanders. Gastroenterology **34:** 484–490, March 1958. (J. M. R., Duke University Hospital, Durham, N.C.)

A series of 556 patients were tested for lipid absorption from the gastrointestinal tract following ingestion of triolein labeled with I^{131}. An additional 46 patients were tested consecutively with radioactive triolein and oleic acid. Details of the test have been previously described (Ruffin *et al.*: New England J. Med. **255:** 594, 1956. Abst. in Radiology **69:** 156, 1957). Concentrations of radioactivity were determined in these blood samples and in stool samples. An average blood concentration above 8 per cent of the ingested dose in the four-, five- and six-hour blood samples is considered normal. Average accumulations of less than 5 per cent indicate severely impaired lipid absorption. Values in the 5 to 8 per cent range are borderline. In normal individuals the radioactive content of the stool is less than 2 per cent of the ingested dose for a collected forty-eight-hour excretion.

The 556 patients are divided into four major groups: Those (1) having previous surgery for peptic ulcer, (2) with diseases of the pancreas, (3) with diseases of the small intestine, and (4) with miscellaneous diseases. The fourth group included primarily individuals with functional disorders or non-gastrointestinal disease. Absorption values of the I^{131}-labeled triolein are presented in tabular form for each of the categories studied. The smaller group, receiving successive testings for triolein and oleic acid, is separately tabulated.

Conclusions are that an accurate reflection of fat absorption is offered by these relatively simple and reliable tests. If the group of patients with previous gastric surgery is excluded, there were no false positive tests in this series. Impairment of digestion as manifested by impaired absorption of triolein was demonstrated in 60 per cent of the tested patients who had undergone gastric operations. In the absence of previous surgery, impairment of absorption of triolein, when combined with a normal oleic acid absorption, is strongly suggestive evidence of pancreatic disease. If both of the lipids show impaired absorption, the primary disease is probably in the small bowel. Use of both lipids in the same patient should thus allow one to distinguish defects of digestion (triolein) from impairment of absorption (oleic acid).

The authors feel that impaired absorption of triolein following gastric surgery suggests that postgastrectomy malnutrition is due at least in part to faulty digestion. The fact that the oleic acid levels were usually normal in this patient group adds further evidence that the error of nutrition is primarily one of digestion rather than absorption.

All 118 patients considered to be in the "functional disorder" group showed normal absorption for triolein, as did most patients with non-gastrointestinal disease.

Eleven tables. JAMES W. BARBER, M.D.
Cheyenne, Wyo.

Inhalation Radiocardiography. H. G. Thode, L. A. Donato, G. H. Debus, P. F. Nace and C. H. Jaimet. Ann. Int. Med. **48:** 537–561, March 1958. (C. H. J., McMaster University, Hamilton, Ontario, Canada)

In inhalation radiocardiography for analyzing the left heart hemodynamics, methyl iodide labeled with I^{131} in a low tracer dose was found suitable in both normal and cardiopathic patients. Animal experiments as well as observations on human subjects showed evidence of absorption of radioactive methyl iodide by the blood and distribution of activity throughout the body a few seconds after inhalation of the tracer. In order to examine the influence of the lungs and bronchial tree on the changing activity of the heart, measurements were made at the manubrium for tracheal activity, in the right infraclavicular as a measure of lung activity, and in the cardiac area.

The results of the authors' studies are reported in considerable detail. Curves of three different types may be recorded on the chest after inhalation of radioactive methyl iodide. None of them is the pure expression of a single process. In the tracheal curve the lung component is not without effect, nor are tracheal and bronchial effects lacking in lung curves. The same factors influence the heart curves, with their bronchial background. However, the experimental results permit analysis of some unique properties of the heart curves. The three important characteristics are as follows: (1) The cardiac peak is reached later than the tracheal and lung peak, three and one-half to five seconds after inhalation. (2) The rate is not affected by apnea. (3) Subtraction of the bronchial level yields constant values for the rate.

Analysis of the left heart hemodynamics is essential for cardiovascular diagnosis. The present method, in association with injection radiocardiography, provides a simple, harmless and reproducible tool for the study of the dynamics of the heart. Less than 25 μc. of radioactive iodine is needed for a test, a dosage well within permissible limits for patients. Simultaneous injection

radiocardiography can be performed providing data for calculation of stroke volume and cardiac output.

Eight figures; 9 tables. CARL PONISCHIL, M.D.
Cleveland City Hospital

A Clinical Comparison and Analysis of Radioactive Diodrast, Hypaque, Miokon and Urokon Renograms as Tests of Kidney Function. Chester C. Winter and George V. Taplin. J. Urol. **79:** 573–579, March 1958. (University of California Medical Center, Los Angeles, Calif.)

Using external gamma counting over each kidney in a method previously evaluated (see Winter: J. Urol. **76:** 182, 1956. Abst. in Radiology **68:** 903, 1957), the authors obtained radioactive renograms following injections of I^{131}-tagged Hypaque and Miokon. Results were compared to previously reported studies with Diodrast and Urokon. The test dose varied from 5 to 20 microcuries.

Diodrast, Hypaque and Miokon all yield renograms indicative of renal tubular secretions as well as glomerular filtration. Renograms obtained with Urokon revealed only glomerular filtration. Distinct differences in renal, hepatic, blood, and urine concentration patterns were noted among the four agents.

Diodrast-I^{131}, because of its rapid and active secretion by the renal tubular cells, remains the radioactive contrast medium most worthy of continued investigation.

Six figures; 1 table. DAVID J. RITCHIE, M.D.
University of Pennsylvania

Volumetric, Gravimetric and Radioisotopic Determination of Fluid Transfer in Transurethral Prostatectomy. R. O. Taylor, E. S. Maxson, F. H. Carter, W. F. Bethard, and R. J. Prentiss. J. Urol. **79:** 490–499, March 1958. (North End of Front Street, San Diego 3, Calif.)

The authors studied 25 consecutive patients to determine intravascular absorption of irrigating solution during transurethral prostatectomy using volumetric, gravimetric, and radioisotopic determination of the fluid transfer.

The irrigating solution was prepared by adding NaI^{131} to 1.1 per cent glycine solution in a concentration of 26 microcuries per liter. This concentration was selected empirically after it was found that it would give, roughly, one count per minute per cubic centimeter of absorbed fluid. Two days prior to surgery, patients were given potassium iodide as a blocking agent to the thyroid gland. During the operative procedure the absorption of the radioisotope was obtained by direct detection with a scintillator head placed over the heart of the patient.

The results of the study revealed a close correlation of volumetric, gravimetric, and radioisotopic measurements of intravascular infusion during transurethral prostatectomy. Appreciable amounts of irrigation fluid entered the vascular system in 68 per cent of the patients and 1 patient received 3,400 c.c. of irrigating fluid intravascularly during the course of the transurethral prostatectomy.

The authors conclude that, since appreciable absorption may occur though the operator is unaware that venous sinuses are open, isotonic irrigants should be employed from the beginning of the resection. Three simple clinical signs of intravascular infusion are: (a) bradycardia, (b) rise in blood pressure, (c) agitation. The direct measurements of radioactive irrigating fluid are relatively accurate and simple, and the authors suggest that this method could be of use to give the anesthetist and surgeon warning of excess absorption.

Six figures; 1 table. JOHN A. WARDEN, M.D.
University of Pennsylvania

Treatment of Malignant Blood Diseases by Radioactive Phosphorus. Part I: Clinical Aspects. Ingmar Bergström and Erik Lindgren. **Part II: Hematological Aspects.** Ingmar Bergström. Acta radiol. Suppl. 150, Parts I and II, 1957. (Roentgen Department, Serafimerlasarettet, Stockholm, Sweden)

Following a comprehensive survey of the literature, the authors present an excellent report of 88 cases of leukemia which they treated with radioactive phosphorus during the period from 1948 to 1955:

Immature (acute) leukemia	17
Mature lymphadenosis (chronic lymphatic leukemia)	30
Mature myelosis (chronic granulocytic leukemia)	12
Myeloma (multiple myeloma)	21
Reticulohistiocytosis (reticulosis, polymorphocellular neoplastic hemoblastosis, Hodgkin's disease, and monocytic leukemia)	8

The survival of these patients did not differ significantly from those treated by other methods. In many cases of mature leukemia there was an apparent cancer heredity, which was not found in the immature leukemias. Following treatment in myelosis the spleen decreased in size, and in lymphadenosis both enlarged nodes and spleen were favorably affected. In myeloma skeletal destruction did not tend to progress during treatment but bone lesions already present did not respond.

The conclusions from the clinical study are as follows:

"a. P^{32} damage on different tissues and organs, as put forward in other quarters, is considerably exaggerated.

"b. The continuation of the treatment until the disappearance of the signs of the disease is to be recommended.

"c. The dosage should vary from case to case as no fixed formula can be drawn up. P^{32} can be administered orally to advantage.

"d. As a rule no indication of P^{32} exists in immature leukemia or in reticulohistiocytosis despite the fact that in single cases significant effects may be obtained.

"e. P^{32} treatment is suggested in all cases of myelosis, lymphadenosis and myeloma."

Three figures; 20 charts; 11 tables.

Part II is an extensive analysis of the hematological aspects of the above 88 cases. The following were among the observations made:

Immature Leukemia. The hemoglobin values decreased throughout the observation period. A temporary decrease in the number of leukocytes and immature cells in the blood was considered a therapeutic effect and not in accordance with the natural history of the disease. Thrombocyte counts decreased throughout the observation period. The changes in the thrombocytes or reticulocytes showed no connection with the total P^{32} dose administered.

Bone marrow sections showed in some cases an insignificant and transitional fibrosis. A marked fibrosis, as reported in the literature, was not observed.

Lymphadenosis. The leukocytes and especially the lymphocytes usually decreased markedly during the first six or seven weeks, after which the decrease con-

tinued slowly. Hemoglobin, reticulocytes, and thrombocytes decreased slightly throughout the period of observation. The incidence of anemia was high, but had no relation to the amount of P^{32} administered.

Bone marrow sections showed an increasing fat cell content as a sign of depression of the leukemic process. Fibrosis of a slight or moderate grade was common, often in connection with lymph follicles. Advanced marrow fibrosis was never observed.

Myelosis. The leukocyte values sank rapidly during the first 50 to 100 days and remained relatively constant afterwards. In some cases a complete normalization of the blood picture was attained. Hemoglobin, reticulocytes or thrombocytes were not influenced seriously, except in connection with myeloblastic crises.

Bone marrow sections revealed a recurrence of fat cells as a sign of remission. Slight or moderate fibrosis arose in some cases, severe fibrosis in none.

Myeloma. The blood elements presented throughout a slow, progressive decrease. Anemia, leukopenia, and thrombocytopenia were often severe in the latter stage of the disease. The cell decreases had no obvious correlation to the doses of P^{32} administered.

Bone marrow sections revealed a moderate reduction of the plasmacytic elements, occasionally a slight fibrosis and a rather unchanged fat cell content.

Reticulohistiocytosis. The specific cells in the bone marrow, the spleen, and the blood were markedly resistant to P^{32} treatment. Those changes which were observed in the normal cell series were an expression of the disease rather than a result of the treatment administered.

From a cytologic point of view all cases of mature leukemia and myeloma are suitable for P^{32} treatment. No disadvantages were observed when treating these conditions to such an extent that all cytologic signs of the disease, as seen in the blood and in the bone marrow, disappeared. The limitation of the method applied appears to be the abatement of sensitivity toward further doses of P^{32} during the progress of the disease. The risks which have been used as an argument against P^{32} treatment seem to be exaggerated.

Three figures; 66 charts.

HOWARD J. BARNHARD, M.D.
University of Arkansas

A Study of Dose Levels in Radio-Iridium Gamma-Ray Therapy. J. S. Mitchell and J. L. Haybittle. Acta radiol. **49:** 233–245, March 1958. (Addenbrooke's Hospital, Cambridge, England)

The aim of this study was to evaluate the dose levels for radical radiotherapy with the gamma rays of radio-iridium, Ir^{192}, under standard conditions of field size, fractionation, and overall time. The empirical dose levels selected were based on clinical observation of tissue reactions in conjunction with previous clinical experience and deductions from earlier studies with radium. An attempt was made to obtain corrected values of the dose levels by the use of estimates of the late results, both for cure rates and for high dose effects.

A 75-curie unit of Ir^{192} with uranium metal shielding was utilized. The mean energy of the primary irradiation of Ir^{192} is approximately 0.38 MEV on the basis of half-value layer measurements. The maximum dose rate is 28 r per minute at a source-skin distance of 9 cm. and 14 r per minute at 13 cm.

A comparison is made of the dose levels and clinical results in the treatment of 130 cases of squamous carcinoma of the skin by means of the radio-iridium gamma-ray therapy unit, the usual filtered 220- to 230-kv roentgen-rays at intensities between 30 and 120 r per minute, and radium moulds. Also, 44 cases of carcinoma of the larynx and 104 cases of carcinoma of the pharynx treated by radio-iridium gamma-rays and by filtered 220-kv roentgen-rays, delivered at about 35 r per minute, are analyzed, mainly in connection with the problem of dose levels.

No significant differences were found between the results obtained by treatment with radio-iridium gamma-rays and 220-kv roentgen rays, or, in the cases of carcinoma of the skin only, with radium gamma-rays.

The clinical results presented do not provide any conclusive evidence that in carcinoma of the larynx and pharynx, the use of a short-distance gamma-ray therapy unit instead of conventional roentgen-ray apparatus leads to a higher cure rate. In this particular series the incidence of high dose effects with gamma-rays has also been no less. It is possible that the full advantage of high-energy radiation in this respect may become apparent only when treatment is given by units having depth doses as good as or better than 200- to 250-kv roentgen-ray apparatus.

The authors' experience in the treatment of carcinomas of the larynx, pharynx and skin demonstrates that the original hypothesis that 1.2 r of iridium gamma-rays is clinically equivalent to 1.0 r of 220 kv roentgen-rays is substantially correct.

Eight tables.

C. HELMEN, M.D.
Indiana University Medical Center

The Quality of Iridium Gamma-Rays within a Scattering Medium. J. L. Haybittle. Acta radiol. **49:** 246–248, March 1958. (Addenbrooke's Hospital, Cambridge, England)

As reported in the paper by Mitchell and Haybittle abstracted above, the use of iridium gamma-rays instead of 220-kv roentgen-rays in the treatment of carcinomas of the skin, larynx, and pharynx has not resulted in a reduction in the incidence of high dose effects. Although the mean energy of iridium gamma-rays is 0.38 MEV, the spectrum contains gamma-rays of energy as low as 0.136 MEV. Measurements were therefore made to see if these softer components plus the presence of scattered radiation could markedly reduce the effective mean energy of the beam by the time it reached the tumor.

Measurements with aluminum and graphite chambers were made to compare the quality of 220-kv iridium gamma-rays within a scattering medium with the quality of roentgen rays under the same conditions. The results show that the energy absorption in the inorganic matrix of bone surrounded by soft tissue is appreciably less with iridium gamma-rays than with 220-kv roentgen rays.

Two figures.

C. HELMEN, M.D.
Indiana University Medical Center

Radiation Pneumonitis and Fibrosis: A Complication of Radioiodine Treatment of Pulmonary Metastases from Cancer of the Thyroid. J. E. Rall, J. B. Alpers, C. G. Lewallen, M. Sonenberg, M. Berman, and R. W. Rawson. J. Clin. Endocrinol. **17:** 1263–1276, November 1957. (J. E. R., National Institute of Arthritis and Metabolic Diseases, Bethesda, Md.)

This paper was prompted by the observation that large doses of radioiodine given to patients with pul-

monary metastases from thyroid cancer may produce severe pulmonary damage.

Radioiodine as I^{131} was given orally in doses ranging from 107 to 355 mc. Fifteen cases of thyroid cancer with pulmonary metastases were treated and 2 patients died from what was presumed to be radiation pneumonitis. These cases are presented in detail. In 4 other patients there was x-ray evidence of pulmonary fibrosis. Nine patients are still alive, one and one half to eight years after therapy.

The following criteria for treatment are suggested: 1) In a patient with multiple diffuse pulmonary metastases, the amount of I^{131} irradiation delivered to the chest should not exceed 125 millicuries in any single dose. 2) Multiple doses should be separated by an interval of at least six months. 3) The magnitude of any contemplated dose should be further restricted by hematologic considerations.

Eight roentgenograms; 2 graphs; 3 tables.

WYNTON H. CARROLL, M.D.
Shreveport, La.

Some Observations on the Effect of Cobalt 60 Beam Therapy on Epidermoid Carcinoma During the First Five-Year Study Period. Ivan H. Smith and J. S. Lott. Am. J. Roentgenol. **79:** 406–414, March 1958. (I. H. S., Ontario Cancer Foundation, Victoria Hospital, London, Ont., Canada)

The authors state that the physical advantages of cobalt-60 teletherapy over conventional roentgen therapy can be seen to have a positive clinical significance. They present a review of experience in carcinoma of the oral cavity, larynx, esophagus, and bladder.

A study of 50 cases of *oral carcinoma* treated radically (with a dosage for cure) during the four-year period, 1952–1955, shows that tumor invasion of the mandible can be controlled by cobalt-60 teletherapy. When incorporated in the treated volume, adjacent solitary lymph node invasion shows favorable response. Recurrence following roentgen irradiation can be successfully treated by cobalt-60 teletherapy. Bone necrosis is minimal and skin reactions are decreased, but radioresistance is still a problem.

Of 13 cases of *laryngeal carcinoma* treated radically (for cure) during a three-year period, 1952–1954, 12 were without evidence of malignant disease for a period of one year and nine months to five years. In these cases cartilage necrosis is minimal; subglottic extension (roentgenographically) is not a contraindication to radiation therapy; the treated skin remains soft and pliable, and in the event of failure the patients' chances with laryngectomy have not been jeopardized. Telangiectasia is occasionally noted both in skin and mucosa. The voices are inclined to be husky; the mucous membranes tend to be dry, and early edema seems ultimately to clear away.

Deductions from 18 cases of *esophageal cancer* treated radically (for cure) during the four-year period, 1952–1955, are: Higher doses of radiation are possible with cobalt-60 teletherapy. Lower integral dosage has resulted in almost no constitutional reaction. Local reactions are quite variable. Only 3 serious complications have occurred; mediastinal fistula in 2 cases, probably as a result of resolution of tumor which had invaded the aorta; pulmonary fibrosis in 1 of the 5 survivors, who after forty-eight months is without symptoms; esophageal stricture in 1 of the surviving cases. This has apparently been cured after 2 esophagoscopies and dilatations. The authors feel that in cancer of the upper two-thirds of the esophagus, cobalt-60 teletherapy may well be the preferred initial method of management.

In a study of 22 cases of *carcinoma of the bladder* treated radically during a three-year period, 1952–1954, it was found that radical dosage requires prolonged treatment time; gross appearance and histology of the tumor are important factors influencing the eventual outcome; the bladders after cobalt-60 teletherapy maintain their elasticity and are healthy. Eleven patients remained without disease for thirty to sixty-two months; 2 in the group treated for palliation, with extravesical pelvic extension, had been disease-free for thirty-eight to forty-two months.

Eleven roentgenograms; 1 drawing; 13 tables.

D. D. ROSENFELD, M.D.
Fontana, Calif.

Transit Dose System for Cobalt 60 Rotating Teletherapy Equipment. Carl B. Braestrup, George Hertsch, and Richard T. Mooney. Am. J. Roentgenol. **79:** 400–405, March 1958. (C. B. B., 99 Fort Washington Ave., New York 32, N. Y.)

Measuring the exposure rate of a transmitted beam at a fixed distance from the source gives useful information regarding the dose distribution in the patient. The authors have utilized transit dose information in cobalt-60 rotating teletherapy equipment. The probe which records the transit rotates with the cobalt source, and the transit dose pattern during rotation is recorded on a polar chart. The same polar chart can be used for each treatment of the patient, thus assuring duplication of the dosage distribution. Dosages as determined from the transit response were compared with those assuming unit density material.

In treatment of carcinoma of the esophagus the data indicate that, when lateral fields were used, the absorbed dose as reflected in the transit dose was higher than one would obtain assuming unit density material. For anteroposterior and posteroanterior fields, these doses were almost equal. In the treatment of the pelvis with complete rotation, the effect of the bone in the pelvis appeared to be counterbalanced by low-density parts. The result was that the corrected dose was slightly greater than that obtained using unit-density material throughout. In typical cases requiring irradiation of the thorax, the dose ratio (that is, the dose as determined from the transit response and the dose obtained assuming unit-density material) was relatively low. The effect of the higher tumor density (approximately 0.9 gm./c.c.) tends to offset the effect of the much lower lung density.

Transit response may possibly have some practical diagnostic applications. With a well collimated beam from a gamma source of a few millicuries, automatic scanning devices can move across parts of the body and provide graphs showing relative attenuations.

Seven figures; 3 tables. D. D. ROSENFELD, M.D.
Fontana, Calif.

The Absorption of Sodium from the Human Urinary Bladder. C. G. Vivion, C. J. Hlad, and B. Eiseman. J. Urol. **79:** 471–473, March 1958. (Denver VA Hospital, Denver, Colo.)

Sodium 24 was instilled into the urinary bladder of patients with chronic and acute cystitis and of patients with no known urinary disease. Studies of plasma and

urinary levels of the isotope showed no significant absorption from the bladder, nor was this affected by variation of the sodium concentration or *p*H of the instillate. [No mention is made as to whether the volume and the state of distention of the bladder were also determined.]

On the basis of the 20 subjects studied, the authors conclude that the absorption of sodium from the urinary bladder is probably not a factor in the sodium diuresis seen after relief of acute and chronic urinary obstruction.

One graph; 1 table.

LESLIE M. ZATZ, M.D.
University of Pennsylvania

Studies in Nonmyxedematous Hypometabolism. II. Turnover of I^{131}-Labeled Thyroxine After Intravenous Infusion. George S. Kurland, Jesus G. Bustos, Milton W. Hamolsky, and A. Stone Freedberg. J. Clin. Endocrinol. **17:** 1365–1372, November 1957. (Department of Medicine of the Harvard Medical School, Boston, Mass.)

The term "euthyroid hypometabolism," has been utilized to describe a group of patients having basal metabolic rates below −20 per cent in association with a variety of clinical symptoms suggestive of hypothyroidism but in whom other customary parameters of thyroid function are within normal limits. The concept that the low metabolic rate might be the result of a defect in the peripheral metabolism of thyroxine received support from the experience of the authors, who treated such patients with triiodothyronine or with mixtures of triiodothyronine and thyroxine. In each of 4 cases, the basal metabolic rate was persistently elevated following the oral administration of triiodothyronine, alone or with thyroxine, although equivalent doses of desiccated thyroid had been ineffective.

Previous studies in these patients failed to reveal any abnormality of thyroidal function as measured by the serum levels of protein-bound iodine and cholesterol, or by the 24-hour thyroidal uptake of I^{131}. With the use of I^{131}-labeled *l*-thyroxine, it was possible to investigate more directly the peripheral metabolism of thyroxine.

I^{131}-labeled *l*-thyroxine was infused into 12 euthyroid hypometabolic patients and 10 normal control subjects. From the curve of thyroxine disappearance, the thyroid and urinary radioactivity, and the level of plasma protein-bound iodine, calculations were made of the half-time of plasma radioactivity, the thyroxine distribution space, volume of distribution, extrathyroidal thyroxine, and thyroxine degradation rate.

The mean half-time of disappearance of thyroxine from plasma was slower (8.3 days) in the euthyroid hypometabolic group than in the control group (7.18 days). No significant difference was noted in mean thyroxine space, volume of turnover, and thyroxine degradation rate. Three patients had low thyroxine degradation rates of 20–27 micrograms per day.

The present limited number of observations point to a possible abnormality in thyroxine metabolism in euthyroid hypometabolic patients.

Two figures; 2 tables.

WYNTON H. CARROLL, M.D.
Shreveport, La.

Factors Affecting the Binding Capacity of Human Erythrocytes for I^{131}-Labeled l-Thyroxine and l-Triiodothyronine. K. R. Crispell, Joseph Coleman, and Harry Hyer. J. Clin. Endocrinol. **17:** 1305–1312, November 1957. (Department of Internal Medicine, University of Virginia School of Medicine, Charlottesville, Va.)

The presence of human plasma markedly inhibits the uptake of *l*-thyroxine and to a lesser extent *l*-triiodothyronine. This inhibition was considered to be due to the binding of *l*-thyroxine by the "thyroxine-binding protein" of plasma. Data are presented to show that human serum albumin inhibits the uptake by the red cell of radioactive *l*-thyroxine and *l*-triiodothyronine, but to a lesser degree than by an equal amount of human plasma, and that human gamma globulin causes no significant decrease in the uptake of radioactive *l*-thyroxine by the red cells.

It is also shown that the addition of stable *l*-thyroxine to plasma decreases its binding properties for radioactive *l*-thyroxine while apparently not affecting the binding sites on the red cell; that the duration of contact of the hormone with the red cell is a factor influencing the ultimate uptake of labeled thyroid hormones; that the vital dyes, Evans blue and Trypan blue, differ in their effects on the binding of radioactive *l*-thyroxine by red cells and by plasma. Trypan blue appears to compete with *l*-thyroxine for binding points on the "thyroxine-binding protein," whereas Evans blue has no effect.

Four figures; 1 table.

WYNTON H. CARROLL, M.D.
Shreveport, La.

Tritium Tracing—A Rediscovery. Nucleonics **16:** 62–67, March 1958.

This paper, for which no author is given, is based on material presented in a Symposium on Tritium in Tracer Applications held in New York in November 1957, under the chairmanship of F. Marott Sinex, Boston University School of Medicine.

There has recently been a revival of the use of tritium as a tracer. Three factors have contributed: (*a*) a drop in price to $2.00 per curie; (*b*) improvement in methods of detecting the (18 kev max.) beta particles; (*c*) the development of a variety of labeling methods.

Various methods of labeling are described, a good deal of attention being devoted to the gas-exposure technic. This method requires isotopic purity, high tritium pressures (about 1 atmosphere), and a large surface area in the exposed sample. Beta particles activate either gaseous tritium or the molecules of the compound and this promotes exchange between hydrogen in the molecule and gaseous tritium. A description and diagram of typical apparatus used for this method are presented.

The incorporation of tritium is expressed in terms of G_T, the number of tritium atoms incorporated per 100 ev absorbed. Values of G_T are given for the gas exposure technic for both the crude mixture and the purified parent. Comparable G values for the tritium recoil method of labeling are smaller by a factor of 10^6, indicating that radiation damage may be expected to be considerably smaller for the same amount of labeling when the gas exposure technic is employed.

Other methods of labeling are: the recoil method, in which use is made of energetic tritons from the Li^6 (n, α) T reaction in a nuclear reactor, and the simpler methods of reduction, simple exchange, hydrolysis, and synthesis by means of intermediates.

Tritium beta particles have a maximum energy of 18 kev, which means that few of them will penetrate even the thinnest window. This difficulty has been overcome by the use of liquid scintillation and gas-counting

technics. In the former the sample is dissolved or suspended in the scintillating liquid or gel. Thus there is essentially no barrier between sample and detector. The beta energy is converted into light which can traverse the scintillating substance without the absorption experienced by beta rays. In the other method tritium-labeled gases are introduced into the sensitive volume of the counter itself. The counter may be operated as a conventional G-M counter or as a gaseous scintillation counter. An account is given of the general requirements of a scintillating solution and of the electronic equipment necessary.

Radioautography with tritium is particularly effective, since the short range in emulsions leads to extremely fine resolution. On the other hand, exposures of several months are often necessary.

Finally, some applications of tritium labeling are discussed. In the manufacture of pharmaceuticals it provides a method of studying new drugs, and petroleum engineers have found it useful in the study of fluid flow.

The article concludes with a bibliography containing forty references to recent work in the field.

Four figures; 3 tables. R. GARRETT
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RADIATION EFFECTS

Can Radiation Cause Thyroid Cancer? Editorial. B. J. Duffy, Jr. J. Clin. Endocrinol. **17:** 1383–1388, November 1957. (Department of Medicine and Radioisotope Laboratory, Georgetown University Hospital, Washington 7, D. C.)

There have been repeated reports indicating an association between therapeutic x-irradiation of benign disease in childhood and the later development of thyroid cancer in a small, but highly significant, number of children so treated.

The experimental work indicates that the administered irradiation is potentiated by endogenous endocrine activity in the development of thyroid cancer. Such a mechanism may account for an increased risk after the use of x-rays in the infant or growing child, compared to that in the adult.

This review of clinical and radiobiologic data on the relationship between radiation and thyroid cancer suggests: (1) restriction of the use of I^{131}, including tracer doses, in the young patient until results of further studies of radiation carcinogenesis in the neonatal and childhood period are available; (2) no restriction of the use of therapeutic doses of I^{131} when indicated in the adult patient, since there is no evidence, clinical or experimental, that radiation can cause cancer in adult thyroid tissue.

One table. WYNTON H. CARROLL, M.D.
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Response of Radiation Pneumonitis to Adrenocorticoids. Philip Rubin, J. Robert Andrews, Richard Paton, and Arnold Flick. Am. J. Roentgenol. **79:** 453–464, March 1958. (P. R., Strong Memorial Hospital, Rochester, N. Y.)

Since its discovery, cortisone has been useful in suppressing a wide variety of inflammatory lesions, some of which are pathologically similar to the pulmonary changes following irradiation. The application of steroids in the treatment of radiation pneumonitis has received increased attention in recent reports. Two cases are here presented in which cortisone was employed with temporary dramatic remission in signs and symptoms, but failed to alter the ultimate course of the disease.

The development of radiation pneumonitis and its response to cortisone can be divided into three main categories: the physical factors of radiation therapy, the biological aspects inherent in tissue response, and the therapeutic regimen employed. The severity of the reaction in lungs can be related directly to the physical factors of the radiation treatment. These include total dosage, the rate of administration, and the percentage of the total lung volume irradiated. No exact equation of the aforementioned variables can be derived which will predict the degree of radiation changes; however, the higher the total dosage, the faster the rate of administration of irradiation, and the larger the lung volume incorporated, the greater is the likelihood of pneumonitis.

The latent period and severity of the pneumonitis and fibrosis are due in some measure to inherent biologic factors. In some cases radiation changes were acute and occurred during the course of therapy, while in other cases the radiation reaction was delayed for a period of weeks to months.

Prompt institution of cortisone treatment necessitates close observation of those patients in whom pneumonitis is likely. The earliest findings may be a spiking temperature with a negative chest roentgenogram, or lack of symptoms despite parenchymal infiltration roentgenographically. Large doses of cortisone, 300 mg. daily, were employed initially and maintained during the acute phase of the disease. There was usually a rapid fall in temperature and improvement in pulmonary symptoms, followed in a few days by regression of infiltrative x-ray findings. The minimum dose for suppression of symptoms was then determined. From the authors' experience, symptoms gradually recurred at this maintenance dose and increasingly larger doses became necessary to reverse the radiation changes. Complications of large steroid doses may preclude further treatment. Subacute and chronic changes may occur despite suppression of the acute phase. Similar progression has been observed in other chronic lung diseases and suggests that the eventual outcome may not be altered by use of cortisone. The clinical dosage employed can only temporarily inhibit the radiation reaction and eventual fibrosis.

While the final status of the adrenocorticoids in the therapy of radiation pneumonitis remains uncertain, they would seem to be of most benefit in patients in whom the radiation changes would regress spontaneously, by suppressing an otherwise fatal acute phase.

Fifteen roentgenograms; 2 graphs; 3 tables.
NORMAN L. ARNETT, M.D.
Upland, Calif.

The Development of Radiation Cataract in Relation to the Water Content of the Lens. U. Ehling and E. Krokowski. Fortschr. a. d. Geb. d. Röntgenstrahlen **88:** 360–365, March 1958. (In German) (U. E., Max-Planck-Institut für vergleichende Erbbiologie und Erbpathologie, Ehrenbergstr. 26/28, Berlin-Dahlem, Germany)

Ionizing irradiation produces in the lens of young rab-

bits opacities and inhibition of growth, probably due to some alteration in the metabolism. To determine if the irradiation damage can be modified by dietetic measures, the following experiment was conducted: 56 rabbits, twenty to twenty-three days old, were subjected to a single dose of 2,200 r applied to one eye only. The physical factors were 60 kv, 4 ma, focal spot-eye distance 4 cm., field 2 cm. in diameter.

The animals were divided into 2 groups. Group A received fresh green fodder and plenty of water; Group B received standard prepared fodder and a restricted water intake. In Group A animals, a marginal cataract developed about twenty-five to thirty days after the irradiation and became complete about forty days after the irradiation. In Group B, the same changes occurred but were delayed about ten days. The development of the lens seemed to be normal up to the thirtieth day. From then on the water content gradually increased to such an extent that the irradiated lens weighed more than the healthy lens, though the dry weight (after the extraction of water) diminished. Again, in the animals of Group B these processes were delayed.

Roentgen rays will block the synthesis of desoxyribonucleic acid, thus producing diminished and abnormal mitoses. The disturbed differentiation of the fibers of the lens may increase the permeability to water, producing the increased water content and then the cataract. The amount of damage to the lens is, up to a certain degree, directly proportional to the amount of irradiation given. A dose of less than 1,600 r will produce a cortical cataract but, if the dose is increased to 1,600 r or more, a total cataract will develop. All these data apply to young rabbits only. In older animals the changes are less pronounced, due to the diminution in the metabolism of the lens, and it is assumed that a restriction of water intake will delay the changes still more.

Three figures; 3 tables.

WILLIAM A. MARSHALL, M.D.
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X-Irradiation-Induced Mitotic Abnormalities in Mouse Liver Regenerating after Carbon Tetrachloride Injury. I. Total-Body Irradiation. Mary Day Albert. J. Nat. Cancer Inst. **20:** 309–319, February 1958. (Huntington Memorial Hospital, Boston, Mass.)

The effects of x-rays upon mitosis initiated in the liver of the mouse by carbon tetrachloride injection were studied. Total-body irradiation (125-1,000 r) produced no visible cytological changes in the liver in a control series. In all livers stimulated to mitosis, however, x-rays had a profound effect upon mitotic figures, regardless of whether the livers were irradiated before or after the initiation of mitosis. Despite the large number of abnormal mitotic figures produced, carbon tetrachloride damage was not enhanced and liver repair was not profoundly affected by irradiation.

The mitotic abnormalities studied consisted of bridges of chromatin material between the separating plates. The bridges varied in length, width, and number of strands present.

As the x-ray dosage was increased, there was a concurrent increase in the percentage of abnormalities: 125 r, 2 per cent; 500 r, 20 per cent; 700 r, 39 per cent; 1,000 r, 52 per cent.

The intensity of the effect was not diminished with passage of time. The percentage of mitotic abnormalities obtained when cells were induced to divide by administration of carbon tetrachloride, 257 days after irradiation, agreed closely with the figures obtained when animals were similarly treated and sacrificed two days after irradiation.

The time of irradiation with respect to carbon tetrachloride injection determined to some degree the percentage of mitotic abnormalities produced. Irradiation two or three days after carbon tetrachloride injection resulted in a slightly higher percentage of mitotic abnormalities than when the injection followed the irradiation.

Eighteen-day-old animals averaged 11 per cent abnormalities compared to 20 per cent for a similarly treated group of adult animals.

The effect of repeated small doses of irradiation (125 r) was cumulative, whether the animals were irradiated daily or at five- to seven-day intervals.

The following conclusions were reached: (1) Resting liver is only slightly less sensitive to x-irradiation than regenerating liver; (2) X-ray effects are less prolonged and persist, but are brought to light only if the cells are forced to divide.

X-Irradiation-Induced Mitotic Abnormalities in Mouse Liver Regenerating After Carbon Tetrachloride Injury. II. Partial-Body Irradiation. Mary Day Albert. J. Nat. Cancer Inst. **20:** 321–328, February 1958. (Huntington Memorial Hospital, Boston, Mass.)

The investigation described in the preceding abstract was continued, in a series of studies with various kinds of shielding, to determine whether mitotic abnormalities observed in the liver were due to direct action of x-rays, secondary systemic effects, or a combination of both.

(a) In experiments in which the liver region was irradiated while the head and tail regions were shielded, the percentage of mitotic abnormalities, though somewhat lower, paralleled results for animals exposed to total-body irradiation.

(b) In the reverse experiments, in which the liver region was shielded, the percentage of mitotic abnormalities was very low.

(c) In the more precise shielding experiments, animals were operated upon and the left lateral lobe of the liver exposed and irradiated; or the left lateral lobe was shielded while the remainder of the animal was irradiated. In both instances, few abnormalities were observed in the tip of the exteriorized liver lobe.

These experiments indicate that although direct irradiation is necessary for obtaining a high percentage of abnormalities, little damage occurs unless other areas of the animal have been irradiated. This constitutes strong evidence for the importance of a humoral factor or factors in irradiation injury.

Five figures; 1 table.

Inhalation Hazards in Nuclear Energy Programs. Stable Elements. G. W. H. Schepers. Dis. of Chest **33:** 121–141, February 1958. (University of Michigan, Ann Arbor)

The author points out that mining and processing of radioactive materials for the production of nuclear energy has complicated the industrial picture as far as the pneumoconiosis is concerned. So-called rare earths which were in the past dealt with in very small quantities are now expected to be employed on a large scale, particularly beryllium. Prior to 1931 less than

100 pounds of this metal were consumed annually for all industrial purposes in the United States. Ten years later the annual consumption approached 30,000 pounds and it is predicted that by 1960 more than a million pounds will be needed to support the nuclear reactor programs in addition to the multifarious metallurgical uses of the element.

Being the portal of entry of inhaled particles, fumes or gases, the respiratory tract calls for first consideration in assessing the biologic effects involved in the nuclear energy programs. Among the pulmonary effects the most spectacular are the local accumulation of foreign particles, focal fibrosis, cellular and stromal necrosis, chronic macrophage catarrh, epithelialization of alveolar walls, granuloma formation, and vascular changes.

The possibility of carcinoma arising as a result of very small amounts of irradiation is touched upon, and it is pointed out that tiny particles containing a great deal of radioactivity may well produce neoplasia, especially if there are additive or synergistic chemical effects.

It is important that differentiation be made concerning the biological actions of the stable elements as contrasted to the effects of radioactivity, lest the two be confused and the underlying pathological state be erroneously assigned.

The author points out clearly that practically all the hazards, whether they are due to chemical action or radioactivity, are preventable by engineering methods. The possibility of remote effects is also considered. The capacity of the lung to absorb soluble compounds is stupendous. On being inhaled, such substances pass to remote organs with almost the same facility as when they are injected intravenously. Uranium, for example, produces a renal lesion equivalent to nephritis.

One roentgenogram; 18 photomicrographs; 1 diagram; 1 graph.

SYDNEY F. THOMAS, M.D.
Palo Alto, Calif.

The Program of the Atomic Energy Commission for Control of Inhalation Hazards of Nuclear Energy Operations. H. D. Bruner and Charles L. Dunham. Dis. of Chest **33:** 142–149, February 1958. (U. S. Atomic Energy Commission, Washington, D. C.)

This article is worth reading in its entirety for anyone concerned with radiation hazards produced by reactors. The Atomic Energy Commission's broad activities bring it into contact with many situations and compounds which affect the lungs. Most of them, fortunately, are familiar industrial problems for which there are acceptable solutions. Superimposing radiation, however, has necessitated major research and development efforts aimed at controlling contamination and the effects of radiation.

Fortunately most of the reactors used in the Atomic Energy Program have very little chance of producing any great inhalation hazard. Many of the reactors use a fluid fuel or a liquid cooler moderator and the power surge results in dispersion of the radioactive liquid within the shell or building enclosing the reactor. Again this is easily detectable and does not produce an inhalation hazard.

Disposal of the waste products for "poisoned" fuels, of course, gives much concern. The program set up by the late Dr. Joseph Hamilton is contained in the National Bureau of Standards Handbook No. 52, shortly to be revised to include recently accumulated data.

Some measures to combat the effects of internal contamination are outlined.

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The Public Health Aspect of Nuclear Energy, with Particular Reference to Inhalation Hazards and to Diseases of the Chest. Albert L. Chapman. Dis. of Chest **33:** 150–155, February 1958. (Division of Special Health Services, U. S. Public Health Service, Washington, D. C.)

The author distinguishes between acute and chronic effects of exposure. Acute effects result from serious accidents caused by large radiation exposures. Chronic low-level radiation exposure is the more important public health problem at the present time.

From the public-health point of view the wartime and subsequent military employment of atomic energy is only one of several sources of total population exposure to radiation. Three chief sources of radiation exposure which constitute the purely civilian aspect of the problem are peacetime atomic energy industry; natural radioactive substances in the environment and those from cosmic rays; exposure to x-rays.

Technics of industrial or occupational health are dealing with inhalation hazards in industrial atomic energy programs. A major activity of the Public Health Service has been the initiation of research into the problem of adequate control measures for the uranium mines, which has resulted in a series of periodic physical examinations of the miners and proper ventilation of the mines to reduce the concentration of radon and its daughter products to a recommended level.

The largest source of radiation exposure is that related to the healing arts, namely, exposure to x-rays. At the present time it is estimated that 250,000 individuals in the U. S. are engaged in the operation of about 125,000 medical and dental x-ray and fluoroscopic units. The ultimate responsibility for the establishment and enforcement of uniform radiation health standards remains with State and local health agencies, but Federal contribution can be as effective as in other areas of public health. Technics are available for reducing the exposure from x-ray and fluoroscopic machines without affecting their diagnostic quality. Existing training programs developed by the Service will be supplemented by short courses for health agency medical personnel.

The Public Health Service Program is one of training, research, and the dissemination of information.

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